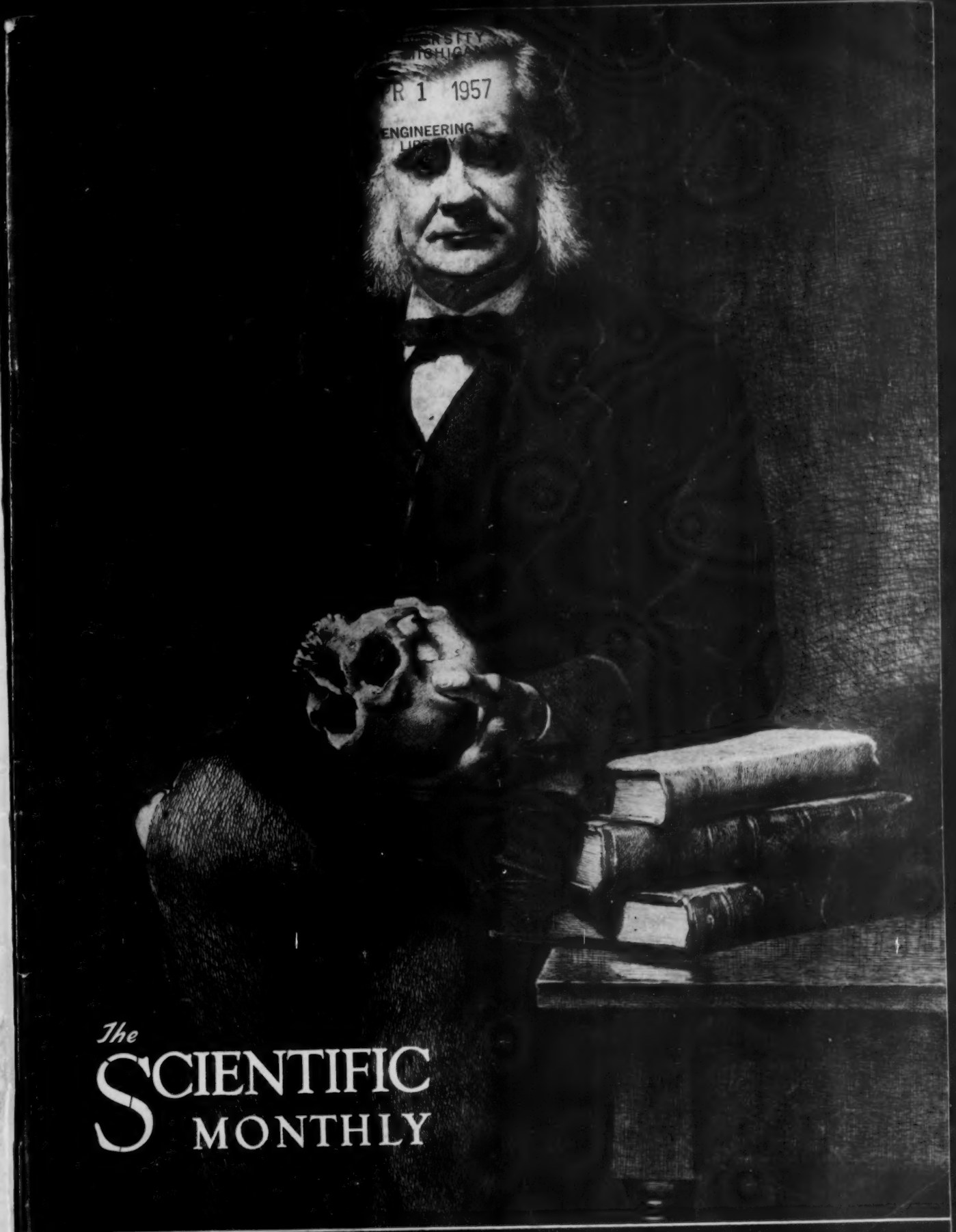

The SCIENTIFIC MONTHLY

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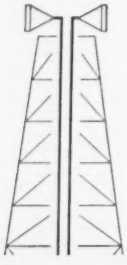
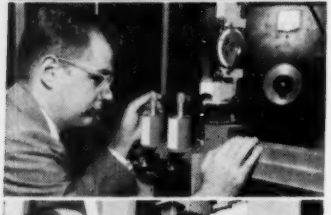
What kind of men develop microwave highways?



The great microwave systems that relay telephone conversations along with television programs from coast to coast will have to work harder than ever to meet growing demands for service. But at Bell Laboratories scientists have been making important advances in the art of microwave communication. These advances are being applied in the development of a new and more efficient system in which single beams of microwaves will carry simultaneously many more telephone conversations and television programs than is now possible.

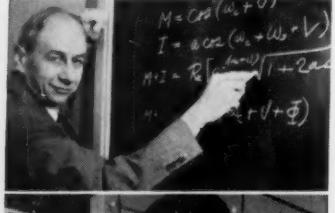
The development of the new system demands the varied skills of men in many fields of science and engineering. Just a few of the specialists necessary are . . .

PHYSICISTS like J. A. Weiss, Ph.D. in Physics, Ohio State, to harness the properties of ferrites in new ways for better control of the transmission of microwaves.



MICROWAVE ENGINEERS like P. R. Wickliffe, M.S. in E.E., M.I.T., to design new circuitry. Microwaves must be conducted, controlled and amplified through waveguides which resemble pipes.

MECHANICAL ENGINEERS like W. O. Fullerton, B.S. in E.E., Iowa State, to embody new principles in designing the many structures and devices used in microwave telephony—with all parts feasible to manufacture, practical to install and easy to maintain.



SYSTEMS ANALYSTS like J. P. Kinzer, M.E., Stevens Institute, for over-all system planning and prediction. Mr. Kinzer works with numerical quantities and characteristics to predict on paper the performance of an operating system. What will it do? How must it perform to meet the needs?

ELECTRONIC ENGINEERS like B. C. Bellows, B.S. in Engineering, Cornell, for the development of "watch-dog" equipment to protect against failure. Protective devices must operate automatically in split seconds to maintain uninterrupted service.

BELL TELEPHONE LABORATORIES

World center of communications research and development

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[*Courtesy Imperial College of Science and Technology, see page 196*]

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All correspondence should be addressed to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts and photographs or for the statements and opinions expressed by contributors.

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Annual subscriptions: $7.50, domestic and foreign. Single copies, 75¢. Special rates to members of the AAAS.

THE SCIENTIFIC MONTHLY is indexed in the *Reader's Guide to Periodical Literature*.

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Science and Technology

All inquiries concerning items listed here should be addressed to The Scientific Monthly, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

Voltmeter

Digital d-c voltmeter for applications requiring 3-digit measurement provides automatic measurement from 0 to 999 v, automatic polarity indication, automatic range selection, and automatic readout decimal point location. The instrument has an oil-sealed, stepping-switch system, and it presents readings in luminous, in-line numerical display. (Non-Linear Systems, Inc., Dept. M68)

Glycerine

A new booklet entitled "Glycerine" defines terms, describes tests, and presents technical data on various grades of glycerine. The booklet includes detailed specifications covering classification, physical and chemical requirements, test procedures, packaging, storage, and use. (Glycerine Producers' Association, Dept. M109)

Spectrometer

A new four-element flame Spectrometer provides simultaneous analysis of sodium, potassium, calcium, and magnesium in biological samples. The instrument consists of a collapsed-beam version of a Wadsworth 750-mm, concave-grating spectrometer and associated electronic circuits. It requires a 1-ml sample. Exit slits are located on the peaks of the lines giving the greatest sensitivity for sodium, potassium, calcium, and magnesium. Additional slits observe the background on one or both sides of the lines. The photomultiplier output for the background is electronically subtracted from the output for the line plus background. Concentration ranges are as follows: sodium, 0.01 to 30 ppm; calcium, 0.1 to 100 ppm; potassium and magnesium, 1.0 to 1000 ppm. The precision is approximately ± 3 percent at 1 ppm for sodium and calcium and at 10 ppm for potassium and magnesium. (Jarrell Ash Co., Dept. M124)

Centrifuge

Heavy-duty centrifuge operates at speeds from 1200 to 4500 rev/min at forces from 290 to 3200 *g*. The unit, which has interchangeable heads, has capacity for 15-, 50-, and 100-ml tubes, 250-ml bottles, and 3-lit flasks. Storage space for extra heads, shields, and trunnion rings is provided. (International Equipment Co., Dept. M118)

Serum Standard

Clinical chemistry control serum for use in blood-chemistry analyses has been packaged for laboratory use. The standards are prepared from fresh human blood and dried rapidly at low temperature. All standards are analyzed by three different participating laboratories to assure accuracy. Addition of 5 ml of distilled water to the standard reconstitutes the serum, which remains stable for 5 days if it is stored at 2° to 5°C. (Hyland Laboratories, Dept. M116)

Bromine Container

Bromine is being packed in an amber glass reagent bottle that has a reusable screw cap. The cap is lined with asbestos, lead, and Teflon. (Mallinckrodt Chemical Works, Dept. M112)

Petri Dishes

Petri dishes containing ready-to-streak culture media are packed in sterile polyethylene bags. Nine different culture media used in routine bacteriology and mycology are currently available. The dishes are disposable. (Hyland Laboratories, Dept. M122)

Gas Analyzer

Mass spectrometer that operates on a radio-frequency principle rather than on a magnetic principle is designed for continuous-process stream analysis and control and for laboratory analysis. The new gas analyzer alternately monitors any six preselected gases in the range between mass 12 and mass 100. An accessory permits cyclic monitoring of selected gases at the rate of one every 10 sec. (Beckman Instruments, Inc., Dept. M125)

Temperature Controller

A thermistor is the detecting element of a new temperature controller that provides sensitivity of control of 0.25°F. The unit provides three modes of control—on-off, proportional, and adjustable-differential. It can be used to regulate water baths, ovens, hot plates, heating mantles, and other laboratory equipment. (Fenwal, Inc., Dept. M137)

Viscosimeter

A new viscosimeter has a temperature range of 0° to −65°F. The unit utilizes mechanical refrigeration, and temperature is controlled by an adjustable hydraulic thermostat. The stainless-steel working chamber, which has 6 in. of insulation, is large enough to accommodate several Kinematic tubes. The stirrer is air-driven. (Labline, Inc., Dept. M138)

Nuclear Reactor

Laboratory reactor operates at a 5-watt power level and produces a flux of 10^8 neutrons/cm^2 sec. The core is a 1-ft stainless-steel sphere that holds about 4 gal of enriched uranyl sulfate in water solution. The unit is 8 ft high and 8 ft in diameter; about 6 mo are required for installation. (Atomics International, Dept. M139)

Microscope

Reflecting objective microscope is designed for work in visible, ultraviolet, and infrared light. The reflecting objectives are available in the magnification range from $\times 15$ to $\times 172$. The working distance at $\times 15$ is 24 mm. (Ealing Corp., Dept. M140)

Chart Tape

Self-adhesive acetate fiber tapes in various widths, colors, and designs, can be used in making graphs and charts. The narrower widths can be curved. Graphs or charts can be readily altered by peeling the pressure-sensitive tape off. Tapes come in 15 colors, six widths from 1/32 in. to 1 in., and nine different striped designs. (Anchor Plastics Co., Dept. M146)

Spectrophotometers

Specifications of two models of Cary recording spectrophotometers are described in a new catalog. The two models are designed for use in the visible, infrared, and ultraviolet regions. (Applied Physics Corp., Dept. M141)

Research Reactors

Swimming pool, heavy water, and nuclear test reactors are three types of research reactors described in a new bulletin entitled "Nuclear research reactors." The uses, design characteristics, safety features, and experimental facilities of each of the three reactors are covered. (General Electric Co., Dept. M145)

Monochromators

Grating monochromators covering the range between 220 and 2800 mμ are described in a new bulletin. Three units, for use in the ultraviolet, visible, and infrared regions, are listed. The units can be used as light sources in microscopic studies whenever monochromatic light is desirable. (Farrand Optical Co., Dept. M144)

Decade Scaler

Scaler with five decade units is designed as a general-purpose nuclear-counting instrument. Five plug-in decade units, plus a 100,000th-unit indicator, permit a direct count up to 199,999 without the use of external registers. Over-all resolution time is 1.0 μsec per pulse pair. A pulse-height control allows the sensitivity to be varied, and a single control lever starts, stops, and resets the count and time. (Technical Associates, Dept. M142)

Periscope

Wall periscope permits remote viewing of objects in contaminated rooms through walls from 4 to 10 ft thick. The instrument has a 180-deg scanning angle and is mechanically operated. A camera adapter is an integral part of the periscope, and an optical relay that permits remote viewing into a microscope is available as a separate unit. (Kollmorgen Optical Co., Dept. M134)

Low-Background Counter

Background is reduced to less than 1 count/min in a counter designed for measurement of carbon-14 of very low specific activity. Ultimate sensitivity is 0.05 count/min. Two separate counters, operating under an anticoincidence umbrella of 16 TGC -16 Geiger tubes, are used. The whole is shielded against terrestrial gamma radiation by mild steel bricks. Window thickness is less than 1 mg/cm². Long-term stability results from the plateau slope of less than 1 percent per 100 volts. (Tracerlab, Inc., Dept. M161)

Hygrometer

Electrolytic hygrometer is capable of detecting water concentrations as low as 1 ppm in gas and air streams. It can be used for either continuous or batch sampling in gaseous streams at temperatures up to 100°C. The instrument is equipped with an alarm system, and its output can be used to operate a potentiometric recorder or record-controller. (Beckman Instruments, Inc., Dept. M135)

Photo Printer

Electronic control is utilized by a photo printer in "dodging" negatives during printing. A brilliant spot of light projected from a flying-spot-scanner cathode-ray tube produces the exposure. The spot scans the negative and the printing material. Variations of density in the negatives are sensed and evaluated in electronic circuits that compare the light value provided with the optimum for the printing material. This information is fed back to control the intensity of the printing beam, thus automatically correcting the exposure of each small sample area of the negative. Application to improving interpretability of x-ray photographs, for example, is apparent. (Norden-Ketay Corp., Dept. M164)

Induction Furnace

Titanium and zirconium metals, as well as metal hydrides, can be analyzed for hydrogen with a new induction furnace. The furnace burns the sample in a stream of oxygen, converting the hydrogen and oxygen into water, which is then weighed in a gravimetric bulb. The unit utilizes standard tank oxygen, which is run through the heated sample in a bath of molten iron. (Laboratory Equipment Corp., Dept. M143)

Animal Cage

Activity cage is an instrument for measuring the locomotor activity of rats. The cage, a 6-in. cube, will accommodate rats up to 400 g in weight. The cage suspension is a resilient cantilever beam that permits a slight sidewise motion of the cage in response to animal activity. The motion is integrated, and the integrated accelerations are recorded on a circular chart recorder. (Williamson Development Co., Inc., Dept. M165)

Electron Microscopes

Data on the construction and operation of electron microscopes are presented in a new brochure. The electron optical system, pumping unit, electronic circuits, condenser, aperture, beam wobbler, objective lens, and astigmator, as well as other components, are described in the illustrated booklet. The operating controls and various cameras that can be used with the microscopes are also covered. (North American Philips Co., Inc., Dept. M133)

Physics problems that yesterday were of only academic interest are today the crucial ones in many of the varied activities at Lockheed Missile Systems' Research Laboratories in Palo Alto.

Here Theoretical Physicists Dr. R. K. Landshoff, Dr. F. C. Hoyt, head of the General and Nuclear Physics Division, and Dr. R. E. Meyerott discuss an application of radiation theory to hypersonic flight. Positions are open at the Laboratories in virtually every field of physics related to missile systems research and development. Inquiries are invited.

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THE
SCIENTIFIC MONTHLY

APRIL 1957

Ecology and Overpopulation

LEE R. DICE

The author is professor of zoology at the University of Michigan, where formerly he served successively as curator of mammals in the Museum of Zoology, director of the Laboratory of Vertebrate Biology, and director of the Institute of Human Biology. Previously, he taught at Kansas State Agricultural College, the University of Montana, and the University of Illinois. This article is adapted from a paper presented before the Ecological Society of America at Storrs, Conn., 29 Aug. 1956.

HUMAN ecology covers a broad area which overlaps a number of the more traditional departments of knowledge. The concepts and methods of most of the biological and social sciences are drawn upon, to a greater or lesser degree, by human ecology in its various aspects. In the analysis of the interrelations of people and their institutions with their biotic and physical environments, however, ecology contributes a unique point of view and a comprehensive scope which extends far beyond the limits of any one of the usual teaching departments.

In order to point out some of the fundamental problems, possible applications, and needs of human ecology, I shall discuss a particular problem, overpopulation, from the ecologic point of view. In a brief article such as this, I shall not be able to treat this important and complex subject in as thorough a manner as it deserves. I hope, nevertheless, using overpopulation as an example, to show that the human ecologist may aid in the solution of some important human problems.

Overpopulation in Nature

Overpopulation occurs frequently in nature. If, at any season, the available food is insufficient for the needs of a local population of any wild species, its members have to exist for a time on short rations, and some may starve. If the supply of suitable nesting or breeding sites is inadequate, certain individuals are unable to produce offspring. If crowding causes fighting among the individual members of a species, their feeding and reproductive activities are likely to be disrupted, and certain individuals, especially the very young, may be injured or killed. In all these cases there is overpopulation. Concisely defined, overpopulation is the situation that occurs whenever any population is too abundant for the carrying capacity of its habitat.

Regulatory mechanisms of various kinds operate in natural communities to maintain the population of each member species at a reasonably stable level and to prevent overpopulation as well as underpopulation. Among these mechanisms are physical agencies of several kinds, feeding by herbivores, predation, parasitism, disease, and competition (*1*). As a result of the operation of these regulatory mechanisms the numbers of any overabundant species will usually be reduced, in time, to a level at which it no longer endangers its own future or that of its associates.

Every species, including man, has a potential rate of fertility which, if not controlled, would soon result in the overpopulation of its habitat.

High potential fertility is necessary for every species so that it can recover with reasonable rapidity from any natural catastrophe. In nature, any excess of population so produced is soon removed by the natural regulatory mechanisms. In the best regulated natural communities, the regulatory mechanisms may be so efficient that only slight variations occur from year to year in the population densities of many of the member species. Such fluctuations as do occur are generally related to the annual cycles of season, or to the longer swings of wet or dry, cold or hot, periods of years.

Occasionally, however, the regulatory mechanisms of a local community are unable to control a particular species, which then increases to a point of excessive abundance. Many of these abnormal increases in population are the result of some interference by man, but they sometimes occur naturally. Mass starvation, aided by disease and the attacks of predators, ultimately reduces the population density to a tolerable level. During the period of overpopulation, however, the habitat may have been overexploited, so that it cannot now support the usual numbers of the species. As a result, the population density of the species must decline to a very low level and must remain below normal until the habitat has been regenerated. This is one of the greatest dangers of overpopulation—the likelihood of overexploitation of the resources of the habitat, with consequent deterioration in carrying capacity.

Despite the accumulation of a considerable amount of information about the conditions that lead to overpopulation in nature, ecologists are not yet able to measure and analyze accurately all the factors involved. The factors that may be responsible for sudden increase in the numbers of an insect pest that attacks a valuable food plant, for example, often cannot be ascertained by our present methods of investigation. For most situations in nature, consequently, only very rough predictions can be made about probable population trends.

Culture and Human Population

The relationship of human populations to their habitats is greatly complicated by man's cultural activities. Although population density of human beings is limited by the carrying capacity of the local habitat, in much the same manner as is that of other animals, man is able, through cultural invention, to increase tremendously the productivity of the natural habitat. He is also able to control, to at least some degree, his birth rate and his death rate.

Among the cultural developments which have enabled man to increase the carrying capacity of his habitat are domestication of plants and animals; economic organization, with division of labor; political organization to promote domestic tranquility; formal education; and scientific research. Through these and other cultural devices modern man is able to thrive in certain parts of the world under densities many times greater than those which could be tolerated by preliterate man. The great advances in science and technology made during the past few centuries, in particular, have tremendously increased the carrying capacity of the earth for human populations.

By the development of methods for the control and prevention of infectious diseases, modern man is able to exist and thrive under heavy population densities that, a few centuries ago, would have invited epidemics of pestilence. Through new inventions and the increase and diffusion of knowledge, the carrying capacities of many parts of the world are being further increased. Almost everywhere populations are growing more dense.

Varying Opinions on Overpopulation

Certain students of world affairs are of the opinion that new inventions can be depended on to provide sufficient additional carrying capacity for almost any probable increase in world population. Other students, however, note that the peoples of many countries now live under conditions of extreme poverty, have a low level of education, suffer from malnutrition, and are ravaged by preventable diseases, but that, in certain of these countries, population density is nevertheless increasing rapidly and the degree of overpopulation is becoming worse. It is doubtful whether, in some of these overpopulated countries, any possible increase in carrying capacity can offset the continuing increases in population densities.

The problems of human overpopulation have been discussed recently by many able scholars, of whom I may mention Brown (*2*), Cook (*3*), Hertzler (*4*), Osborn (*5*), and Sax (*6*), to name a few. The *Population Bulletin* (*7*), also, has published many valuable articles dealing with the population problems of specific areas. The general consensus of the men best qualified in this phase of human ecology is that, in certain parts of the world, the available resources are insufficient to provide the existing population with sufficient food and other necessities for maintenance of even a minimum level of living. In most of these countries, nevertheless, the birth rate considerably exceeds the

death rate, so that the overpopulation problem is every year becoming still more acute.

In the United States, fortunately, overpopulation does not now exist, except locally. Our population, however, is growing rapidly. Considerable apprehension exists, therefore, lest within a few decades our country, also, may become overcrowded.

The control of excess population by the natural regulatory mechanisms of starvation, pestilence, and strife has been greatly lessened in many of our modern communities. Nevertheless, these mechanisms are still powerful agents of population control. One or more of these controls is likely to take command whenever and wherever man fails to adjust his population density to the carrying capacity of the habitat. Nearly every year a local population in some part of the world suffers from acute food shortage. There are frequent epidemics of disease fostered by poverty and overcrowding.

Everyone applauds the great decrease in human suffering and heartbreak which has resulted from the recent lowering of the death rate in most parts of the world. We are especially pleased by the lessening of infant mortality. The ecologic balance between population density and the carrying capacity of each local ecosystem, however, must be maintained or disaster will eventually overtake the human society concerned. Birth rates must be balanced with death rates or the resulting overpopulation may bring misery no less grievous than that caused by heavy mortality rates.

Overpopulation and War

Overpopulated areas exert population pressure on their boundaries. This pressure, if intense, may lead to friction, and perhaps war, with neighboring peoples. The causes of war, however, are complex, and population pressure does not always result in armed conflict. Numerous countries which are obviously overcrowded exhibit no tendency to make war on their neighbors. Any overpopulated area must, nevertheless, be considered a potential danger spot in our complexly organized world (*4*, pp. 106–110).

Level of Living

Level of living is an important factor to consider in attempting to specify whether any particular area is overpopulated. For a given volume of available resources, more people can exist at a low than at a high level of living. At a high level of living, there is likely to be waste of resources, including the spending of wealth and labor for frivolous and unnecessary articles and activities. At a low level of living, malnutrition, ill health, and illiteracy will usually be widespread, advance in technology and in other aspects of culture is almost impossible, and there is danger of overexploitation of the natural resources. The exact relationships between level of living, available resources, and population density, however, are difficult to specify. Little precise information about these relationships is available for any particular population.

The rapid increase in population in the United States in recent years is undoubtedly related to the high level of living enjoyed by most of our citizens. Under the conditions of plenty which currently prevail in our country, the level of nutrition is generally adequate. This favorably influences natural fertility. Good sanitation and the adequate medical services which now are available to most of our citizens control the ravages of disease and promote health. The death rate is consequently reduced, and fertility enhanced. A still further effect of freedom from want is a tendency toward increase in the marriage rate and a decrease in age at marriage.

Importance of a Surplus

Overpopulation may usually be considered to exist in any region which fails to have, in most years, at least a small surplus of annual production over current utilization. Such a surplus is necessary to provide a reserve against an unfavorable season or other catastrophe. Any people which absorbs all its production in its daily living is in serious danger of disaster whenever an emergency of any kind arises.

At least some surplus of production is also necessary to provide for the progressive evolution of industry and of other products of culture. This surplus wealth makes possible the construction of factories, homes, stores, railroads, highways, power stations, schools, irrigation systems, sewage systems, and many other private and public works. Invested in this way, surplus wealth becomes capital, which improves productivity and increases carrying capacity or level of living or both. Surplus wealth may also be used to support education and invention, thereby still further increasing carrying capacity (*8*).

In an overpopulated area, however, all available resources are absorbed in keeping the population alive, and no surplus exists to finance the construction of works or of machinery which might increase productivity or support further evolution of

the culture. On the contrary, in an overpopulated area the existing culture is in danger of stagnation or deterioration.

Proposed Remedies

Many countries in which the birth rate is high have widespread poverty and a low level of living. Countries with a low birth rate, conversely, usually have a high level of living. Some students have consequently assumed that if the level of living in the overpopulated countries could be raised, their birth rates would fall. In this way their overpopulation problem would be solved. That birth rates will be lowered by the bringing in of industries seems, in particular, to be widely believed.

It is a fallacy, however, to assume that poverty promotes fertility, or that prosperity causes a decline in birth rate (*5*, p. 214). On the contrary, when food is plentiful and the cost of living is low in relation to income, the birth rate tends to be high. In the United States, during the depression years of the 1930's, for example, the birth rate declined, while in the boom years during and following World War II, the birth rate increased and has since remained at a relatively high level.

The relationship between birth rate and level of living is undoubtedly closer and more direct in a country such as the United States, in which the practice of birth control is widespread, than in countries in which little or no conscious attempt is made to control births. In every country, nevertheless, any improvement in nutrition or in public health may be expected to result in an increase in fertility rather than in a decrease.

In a country where the birth rate has been lowered, so that the population and the available resources are in equilibrium, any increase in resources can be applied to raise the level of living. Control of births, according to this thesis, precedes and makes possible a rise in level of living.

There is a noticeable decline in the birth rate of any people or class which is exposed to the influence of modernization. The application of some degree of birth control seems always to be the effective factor. However, practice of birth control sufficient to bring the birth rate of an underdeveloped country into adjustment with its carrying capacity requires, in most cases, drastic changes, not only in technology and economics, but especially in social and political practices. Important changes in education, social ethics, and religion are usually necessary. These changes, however, may bring unhappiness and confusion to many people. The required changes in point of view and in way of life cannot easily be achieved (*4*, chap. 6).

Underdeveloped Countries

The giving or lending of materials or money to underdeveloped countries which are now overpopulated in relation to their resources, and in which the population is still growing, usually fails to produce any permanent remedy for overpopulation. Shipments of food, for example, can at best only temporarily alleviate hunger. If the people remain as numerous as before, or increase in numbers, their hunger will be as great as ever when the food shipments cease, as they must in time. Loans or gifts of money, no matter how great, are certain to be absorbed, probably leaving more hunger than before. It is evident that an impoverished country is not likely ever to be able to repay a loan, even if no interest is charged. Most such transfers of money or materials must consequently be treated as gifts. The donor country, however, is not likely to receive any special gratitude. On the contrary, it may be criticized if greater and still greater gifts are not made each year.

All possible assistance should, of course, be given to underdeveloped countries to aid them in improving their technology; their educational facilities; their economic, social, and political organization; and their public health. But aid in these fields can have little permanent effect unless the population density of the country concerned is brought into adjustment with the available resources.

In a population in which birth rate exceeds death rate, so that population density is increasing, any small increase in wealth, such as might be afforded by a technologic improvement, is almost certain to be absorbed by the increase in population. Only in a very favorable situation, such as has existed in recent times in the United States, where wealth is increasing faster than population, will there be a remainder of wealth to apply toward raising the level of living.

The first and most essential step in helping any underdeveloped nation is to aid it in bringing its population into balance with the present carrying capacity of its land. Improvement in technology aimed at increasing the production of food and other commodities is only one part of such a program. Research on locally practical methods of birth control, dissemination of information on methods of contraception, expansion of educational systems, and research on the ecologic relationships between productivity and consumption in the area concerned, would all pay large dividends by attacking the problem of overpopulation at its source.

When population density of a country is adjusted to its carrying capacity, so that the level of living can begin to rise, the people can be depended on to take the necessary steps toward the evolution of an economy suited to their local situation.

Regional Differences

Regional differences in culture are everywhere evident. Some features of every culture, moreover, are clearly adaptive in relation to the regional climate and local resources. Those customs that affect reproductive rate, for example, must, in general, be adaptive in relation to the prevailing conditions in the habitat, particularly in relation to the factors that cause mortality. Too low a reproductive rate might lead to the extinction of the group, while too high a rate might result in overpopulation. During their past history most societies have evolved customs that maintain a tolerable balance between reproductive rate and mortality rate. In recent years, however, the death rate, particularly in the younger age-groups, has been greatly reduced over large parts of the earth through the control of certain diseases. This decrease in mortality rates has rendered no longer adaptive many ancient local customs connected with marriage and reproduction.

The assumption is often made that the ideals, religion, social values, political system, and standards of morality of one's own country are the best possible. Not only our missionaries but sometimes also our political leaders and industrialists have attempted to proselyte foreign peoples. But the civilizations of certain of these peoples may be older than ours, and may, in some particulars, be better adapted than ours to their local conditions. No one type of civilization can be equally well adapted everywhere in the world. On the contrary, customs, political and social organizations, and technologies that are suited to one region may be wholly unsuited to others.

From the standpoint of the student of evolution, diversity within and among populations is greatly to be desired. Variation in hereditary racial characters provides the materials from which natural selection can create ever better adaptation to the regional climate and more effective resistance against local diseases. Diversity of culture similarly provides a basis for further cultural evolution through selection of the better adapted cultural elements. Uniformity, among nations, of the calendar and of measurements, currency, language, and certain other features of life would certainly be desirable. The world would be a dreary place, however, if all countries and all local populations ever came to have exactly the same technology, customs, philosophy of life, and other aspects of culture.

More Research Needed

Although it will generally be agreed by most students of the subject that overpopulation now exists in some parts of the world, there often is complete disagreement about the presence of overpopulation in a particular area. One writer may state that the nonrenewable resources of the area concerned are being rapidly depleted and that overpopulation already exists. Another author, using the same basic data, may conclude that the natural resources are capable of supporting a population considerably larger than that which now occupies the area.

The widely diverging opinions of the best authorities about the carrying capacities of particular areas clearly indicate that real information about the ecologic relations between resources, state of culture, and human population density is woefully inadequate. When facts are lacking, arguments and disputes abound.

Far more information than we now possess is needed about the relations of human populations to their habitats. Tabulation of the natural resources of each country and state, of the numbers of people according to sex and age class, and of birth rates and death rates, however, is not sufficient. We need to know, for each local area, the social and economic factors that influence marriage rates, birth rates, and rates of utilization of the several resources. We need to know what factors influence death rates, emigration, and immigration. We must also know about the education, ideals, and philosophies of the people, about their institutions, and about their personal qualities and aptitudes. Above all we must learn about the interrelations of the people and their culture with the conditions and resources of their environment—interrelations not only with the physical environment but also with the native and domesticated plants and animals, with disease organisms, and with neighboring peoples.

Much remains to be done toward the development of practical methods for studying human communities. Precise quantitative measures of carrying capacity in relation to state of culture and level of living are urgently needed. To be really useful these measures must be of a practical kind, which can be made, at reasonable expense, by a small staff. The development of methods for true random sampling and for securing information through personal interviews offers considerable promise for research in this area.

The ecologic interrelations within the simplest human community are tremendously complex. This undoubtedly explains why, as yet, we know so little about them. I am firmly convinced, however, that the time is ripe for fundamental attack on these problems. Research in human ecology is not easy. No one person and no one of the usual departments in the biological or social sciences can successfully operate here alone. Research teams composed of both biologists and social scientists are needed.

The study, in the necessary detail, of the ecology of even a single local human community cannot be carried out in the spare time of college or university teachers. My experience in ecologic research convinces me that a special research team must be set up for each project in human ecology. University professors may profitably work with such a project during a leave of absence, in summer, or on a part-time basis, but at least the core of the scientific staff should be employed full time. Five years is probably the minimum time in which any such project, even a small one, can be completed, and the results written up. Each such project will therefore cost a good deal of money. Only through such intensive studies, however, will we ever learn the precise conditions under which overpopulation arises and continues.

Other Problems of Human Ecology

Numerous other problems in the field of human ecology, in addition to overpopulation, are of great concern to man. I may mention particularly the conservation of natural resources, the influence of environmental factors on the evolution of culture, the adaptation of populations to the common diseases of their habitats, and the regulatory mechanisms that operate to maintain stability in human communities. These topics are all related more or less directly to the problem of carrying capacity and overpopulation. All knowledge is, in fact, interrelated, and this is nowhere more true than in the field of human ecology.

Research in human ecology falls in the twilight zone between biology and the social sciences. Increasing attention, fortunately, is coming to be given to this subject, both by social scientists and by biologists. I hopefully look forward to important advances in the near future, not only in our knowledge of population ecology, but in many related phases of human ecology.

The field of human ecology is a promising one for those students who are willing to work for a number of years before being able to publish material of value. It is not to be recommended to those who want to achieve fame quickly. Nor is it recommended to those who are unwilling to train themselves broadly and thoroughly in a number of related subjects. For the person who has imagination, thoroughness, patience, and broad interests, however, human ecology is a wide-open field which promises rich rewards in research.

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Thomas Henry Huxley

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Mr. Blinderman is a lecturer in English at Southern Illinois University. He received his training at New York University and Indiana University. In 1955–56 he went to London on a Fulbright grant to study a collection of unpublished Huxley papers at the Imperial College of Science and Technology, University of London. During the course of these studies, he produced a catalog of Huxley's notebooks on zoology; he also gathered material for a dissertation on Huxley's exposition of Darwinism.

ALMOST a century ago occurred the most dramatic defense of the *Origin of Species* in the entire history of that controversial classic. The scene was the Sheldonian Theatre at Oxford University; the occasion, a meeting of the British Association for the Advancement of Science; the program, a debate on natural selection. The two protagonists were Samuel Wilberforce, Bishop of Oxford, and a tall, dark young man known variously as "William Huxley" or merely "a Mr. Huxley." The bishop had been coached by the anti-Darwinian anatomist Richard Owen and had written a review of the *Origin*, but, knowing little of biology, he was eager to discredit the new speculation for religious reasons. Expecting the bishop to beat the *pas de charge* on the drum ecclesiastic, the audience was more than satisfied when he turned to Huxley to ask him, half-facetiously and half-maliciously, whether he had descended from an ape on his grandfather's or his grandmother's side. Huxley had been impatiently anticipating just such an opening, and he whispered happily, "The Lord hath delivered him into mine hands!"

Perhaps the incident was not precisely what Julian Huxley called it—"in some ways the most decisive event in the history of nineteenth-century thought" (*1*)—but it did have at least two decisive consequences. First of all, the new theory was initiated into public notice, not with the whimper which would attend the enunciation of a similar biological doctrine today, but with a bang reminiscent of the enunciation of Galileo's *Dialogo*. It was also a crucial stage in Huxley's own evolution as the foremost scientific controversialist of the period. The relatively unknown anatomist and paleontologist became a noted figure with a gratifying suddenness. Huxley's own contemporaneous letter, the most valid account of the memorable meeting, has recently come to light. He wrote to Frederick Dyster:

"Has the version of the Oxford row reached Tenby? It was great fun. I had said that I could not see what difference it would make to my moral responsibility if I *had* had an ape for a grandfather and saponacious Samuel thought it was a fine opportunity for chaffing a savan [sic]. However he performed the operation vulgarly and I determined to punish him—partly on that account and partly because he talked pretentious nonsense. So when I got up I spoke pretty much to the effect—that I had listened with great attention to the Lord Bishop's speech but had been unable to discover either a new fact or a new argument in it—except indeed the question raised as to my personal predilection in the matter of ancestry—that it would not have occurred to me to bring forward such a topic as that for discussion myself, but that I was quite ready to meet the Right Rev. prelate even on that ground. If then, said I, the question is put to me would I rather have a miserable ape for a grandfather or a man highly endowed by nature and possessing great means and influence and yet who employs these faculties and that influence for the mere purpose of introducing ridicule into a grave scientific discussion—I unhesitatingly affirm my preference for the ape.

"Whereupon there was inextinguishable laughter among the people, and they listened to the rest of my argument with the greatest attention. [John] Lubbock and [Joseph] Hooker spoke after me with great force and among us we shut up the bishop and his party.

"I happened to be in very good condition and said my say with perfect good temper and politeness—I assure you of this because all sorts of reports [have] been spread about *e. g.* that I had said I would rather be an ape than a bishop, etc.

"All the Oxford Dons were there and several hundred people in the room—so that I think Samuel will think twice before he tries a fall with men of science again.

"If he had dealt with the subject fairly and moderately, I would not have treated him in this way —But the round-mouth, oily, special pleading of a man who is ignorant of the subject, presumed

on his position and his lawyer faculty gave me a most unmitigated contempt for him. You can't think how pleased all his confrères were, I believe I was the most popular man in Oxford for full four and twenty hours afterwards" (*2*).

T. H. H., His Mark

The last of seven children, Thomas Henry Huxley was born on 4 May 1825 in Ealing, then a small village on the outskirts of metropolitan London. From his mother, he informs us in his *Autobiography,* he inherited a quick-witted insight and his physical appearance; from his father, who was an assistant headmaster in a small country school, he inherited an ability to draw, a hot temper, and, what was of paramount importance for his later spectacular success, a tenacity of purpose aptly characterized by his referring to himself once as "Darwin's bulldog" (*3*). Huxley's youthful reading foreshadowed his later interests; he consumed popular novels, histories of Europe, works on science, philosophy, and religion, idling away the hours thumbing through a large, illustrated Bible that delighted him. Although he had no formal schooling for 10 years, like Herbert Spencer and other of the self-educated greater Victorians, he occupied himself advantageously in his spare time, speculating on the causes of sunset colors and inventing what he fondly thought was a perpetual-motion machine. After explaining the latter to Michael Faraday, who received him kindly but the machine rather unfavorably, the young boy vowed that some day he would have something of more import to show Faraday.

Throughout the correspondence of the young Huxley there are indications of how strongly honor pricked him on. Suspicious about the virtue of an unbridled ambition, he was nevertheless quite certain that he would impress himself upon his society, writing at one time to his sister: "I will leave my mark somewhere, and it shall be clear and distinct—T. H. H., his mark—and free from the abominable blur of cant, humbug, and self-seeking which surrounds everything in this present world" (*4*). Huxley reiterated this assertion in various forms, and even though he at times came close to canting about his own high honesty and unselfish devotion to the cause of truth, there is no doubt that he was intrepid in his efforts to promulgate the facts of scientific life in the face of social ostracism and unrelenting vilification. He had a work to do in England, a messianic purpose, and he dedicated to that purpose his tireless energy and his vast resources of knowledge and ability. And he did attain the success his heart desired, for Huxley was recognized as a prophet in his own country.

Although the youthful Huxley's own propensity was for engineering, he pursued the course of medical study which had been planned for him by his family. Sometime around 1839, while Charles Darwin was compiling notes on the transformation of species, the teenage Tom Huxley attended a postmortem examination. Weakened by intensive reading, stifled in the close and malodorous atmosphere of an early Victorian autopsy room, perhaps seeing in the dissection of the human body the dissection of his evangelical belief in immortality—whatever the reason—the boy became violently ill and had to be removed to a farm, where he eventually recuperated. This crisis precipitated an attack of "Victorian brain-fever," a malady endured also by Charles Darwin, Herbert Spencer, James Clerk Maxwell, and a number of other 19th-century men of science (*5*). At first, such honors as admission to the Royal Society were for Huxley a satisfactory antidote to the "blue devils" of despair which had been active in the autopsy room; later, after vacations and doctors had proved largely ineffective, he discovered that an excellent cure could be obtained in intermittent eristic combats with bishops, philosophers, other scientists, and stray prime ministers.

Like Darwin, and like the botanist Joseph Hooker, Huxley undertook in his youth a voyage of discovery. The *H.M.S. Rattlesnake*, a "donkey frigate" similar to Darwin's "coffin," was to explore the Great Barrier Reef in order to chart out a safe shipping route for the rapidly growing colonies of Australia. Something of a naturalist, a bright medical student, and a personable young man avid for adventure, Huxley was well qualified to take the position of assistant surgeon under Captain Owen Stanley. After leaving England in December 1846, the ship touched at Madeira and at Rio de Janeiro, then crossed the South Atlantic to the Cape of Good Hope, proceeding from there to Australia. Huxley was well contented with the thought of the advantages lying open to him. "Altogether I am in a very fair way," he wrote a few months before the voyage, "and would snap my fingers at the Grand Turk" (*6*). With John MacGillvray, son of the famous ornithologist, Huxley improvised dredging nets, often finding his specimens kicked off the deck by sailors; nevertheless, the lack of scientific instruments, the necessity of lashing his microscope to the mast, the paucity of scientific literature, and the presence of unsympathetic mates merely threw him upon his own resources.

He was less interested in affixing his name to a new species than in demonstrating the morphological development and the interrelated structures of the transparent animals that were dredged up, hearkening back to his early interest in engineering.

Huxley, as a young man, was an adroit artist. He frequently interrupted his work on oceanic hydrozoans in order to make sketches of the landscapes or of the inhabitants of the countries he visited. These two sketches of natives are reproduced from a volume entitled *Original Sketches by T. H. Huxley,* one of the notebooks extant from Huxley's cruise of the *H.M.S. Rattlesnake.* [From "The Huxley Papers" (*2, 71*), courtesy of the Imperial College of Science and Technology, London]

Of the seven points of study he had listed, he completed only two; neglected was research on the brains of fishes, fish parasites, barnacles, segmented worms, echinoderms, and coral. Huxley devoted his time to a detailed study of the coelenterates and of the structural organization of mollusks. The pelagic animals scooped up by his tow net of bunting were subjected to thorough examination with the microscope and scalpel, and Huxley was able to do first-rate work on mollusks, coelenterates, and tunicates. An accurate draftsman and an imaginative artist, he complemented his writings on these marine creatures with precise drawings, just as he illustrated his notes on South Pacific aborigines with sketches like the ones reproduced here (*7*).

Huxley's earliest scientific paper, written in 1845, described a previously unknown layer in the human scalp, a membrane still known as "Huxley's layer" (*8, 9*). Aboard the *Rattlesnake,* he worked on classifying his specimens, reducing into an established order the Mollusca, previously the dumping-ground of invertebrate life. He frequently dredged up medusae and was fascinated by these transparent, unfamiliar creatures. While working on the systematics of jellyfish, he came across a fact of which he did not recognize the major importance. Research on the foundation membranes of jellyfish, one responsible for the outer surface of the animal, the other for the stomach and internal organs, led him to compare the adult coelenterates with vertebrate chicks. It was a novel advance in embryology and led to the definition of these cell layers as ectoderm and endoderm.

Darwinism

Huxley returned to England late in 1850, having had firsthand contact with the material that was later to be of utmost significance in his life's work, and he immediately set to work transforming his notes into memoirs. His return had been preceded

by the acceptance by the Royal Society of a paper on the medusae, in which Huxley casually made the epochal comparison of coelenterate cell layers with vertebrate embryos; "On the anatomy and affinity of the medusae" resulted in his being elected a fellow of the Royal Society in 1851, at the astonishingly early age of 26, and shortly thereafter his receiving the society's gold medal. Unable to get his papers published by the Navy, and unable to find a position at a university, though he tried Scotland and Canada as well as England, he was heading for poverty, and he had to postpone marriage to his fiancée, whom he had met in Australia. However, he published more than 20 memoirs, quarterly reviews of contemporary science, edited and translated French and German works, and attempted to hammer his reputation—advice he once gave to a young fellow scientist named John Tyndall. Soon he was hobnobbing with the greats of biology, meeting in the early 1850's the men who were to be his life companions and fellow-Darwinists: Herbert Spencer, Joseph Hooker, Charles Lyell, and Charles Darwin himself.

In the spring of 1852 Huxley was invited to give the first of many lectures to the Royal Institution, where Davy had experimented on the electric arc lamp and where Faraday had investigated electromagnetism. He chose as his subject "Animal individuality" (*9*). Huxley had been interested in the reproduction of the tunicates, especially the salps, whose life-history exhibits an alternation of generations as well as of forms. He set out to establish the fact that individuality is predicated not on any particular stage of development but rather on a cycle of beings in which forms may differ vastly. This Friday evening discourse was followed by others in which Huxley discussed the common plans of animal forms, the development and persistence of animal groups, and the origin of species and races.

In these years before the publication of the *Origin of Species*, his attitude was more hostile than favorable toward the theories then current about transformationism: at times, as in a catalog of fossils he helped compile in 1857, he speaks as if the developmental hypotheses could best explain the facts of organic nature; at other times, he implies that animal species were created independently, or explicitly states that some particular aspect of speculation is erroneous. For example, in a lecture on natural history he attacked Cuvier's law of correlation, endeavoring to prove that an entire animal could not be reconstructed from an isolated fossil fragment. Since we cannot prove Cuvier's law of coadaptation of organs to be valid, he concluded, organs are not adapted for purposes of utility. Nature "is not a mechanism, but a poem; not a rough engine-house for the due keeping of pleasure and pain machines, but a palace whose foundations, indeed, are laid on the strictest and safest mechanical principles, but whose superstructure is a manifestation of the highest and noblest art" (*10*).

Darwin read and disliked this transcendentalism, which was destructive of his notion that organs were naturally selected specifically for purposes of utility. When the *Origin of Species* was published, Huxley was frankly amazed; he had known of Darwin's study, but he had not expected such a monumental aggregation of facts all ordered so cogently that he had to give up his previous stand of doubt and accept the new hypothesis. Everything fell into a neat order: the fundamental relationship between the cell layer of an adult jellyfish and an embryonic chick, the anatomical resemblance between an ape and a man, and all the miscellaneous facts of anatomy, of paleontology, of geographic distribution, and of zoology were like pieces of a picture puzzle suddenly assembled into a coherent picture illustrating the evolution of all living things. Huxley was converted almost instantaneously and, like St. Paul, who had been similarly illuminated, he proceeded to convert the gentiles. And he was quite aware of the resentment they would feel toward the proselytizer. "I trust you will not allow yourself to be in any way disgusted or annoyed," he advised Darwin, "by the considerable abuse and misrepresentation which, unless I greatly mistake, is in store for you. Depend upon it, you have earned the lasting gratitude of all thoughtful men. And as to the curs which will bark and yelp, you must recollect that some of your friends, at any rate, are endowed with an amount of combativeness which (though you have often and justly rebuked it) may stand you in good stead. I am sharpening up my claws and beak in readiness" (*11*).

Huxley was ideally qualified to undertake the defense of the *Origin of Species* and to extend the methodology of science into all fields of human thought. Provocation is not always delightful, but it will frequently give rise to entertaining controversy, and in the Victorian Age controversy was located somewhere between an art and a game. It was recognized as a profitable way of satisfying the esthetic demands of human nature, while at the same time providing a sporting means of keeping up with the news. Like Spencer, and like John Tyndall, Huxley was a pugnacious defender of heresy. His appetite for fighting was enormous, and while he modestly depreciated his controversial talent,

blushing at the accusation that he really relished taking up the cudgel, he never resisted the temptation to enter into, or to initiate, one of those long controversies that make the annals of Victorian science exciting reading.

But a hot temper alone is not sufficient for the popularizer of science; he must also have some acquaintance with the material he is to present to the public. Huxley was, with Charles Darwin, the foremost representative of biological science in England during the last century; he made a number of original discoveries, promulgated the discoveries of others, and instructed scores of student investigators, such as Michael Foster and Henry Fairfield Osborn, who disseminated throughout the world his method of laboratory training. The four decades Huxley spent in the laboratory and in the classroom earned for him a respect in the market place he could never have achieved solely on the merits of pugnacity.

Besides the essential basic knowledge that he had at his command and his useful gladiatorial temperament, Huxley was also proficient in the art of persuasion, able to excite those who were left cold by brute facts. Sometimes it was as much to hear a stimulating lecturer who overpowered one with reasoned facts presented in beautiful language as to be educated in the subject that people came to listen to Huxley. He was determined to popularize science outside the small group of wealthy dilettantes who came to show off their finery at the Royal Institution. His determination was that he should be remembered as a friend of the people, but it was to achieve more than posthumous fame as a humanitarian that Huxley undertook in 1855 a regular series of lectures to working men. Displeased with his middle-class audiences, Huxley enjoyed talking to a "fustian audience," and he spared no pains to make his discourses to them as persuasive and enrapturing as his talks to his more sophisticated auditors at the Royal Institution.

"I must and will make people see what grandeur there is [in an] interest in Biological Science," (*12*) he wrote, sometime after he had been given a position as professor of natural history and paleontology in the Royal School of Mines in 1854. Always careful to keep to the mean between the incomprehensibly complex and the insultingly simple, he displayed for his audiences the long range of evolution and the methods by which it was verified by geology, biology, and anatomy, repeatedly asserting that Darwin was the Newton of biology. He freely gave his time to audiences, both lay and professional, and his money to indigent amateurs who were interested in learning about science, for Huxley the man, unlike Huxley the controversialist, was kindhearted, even gentle, and never shirked what was both a duty and a pleasure: the enlightenment of the Victorian mind.

This doodle is from the pages of a draft of the monograph *On the Anatomy and Affinities of the Family of the* Medusae. In addition to illustrating Huxley's penchant for landscapes, it also reveals his interest in grotesques which have a notable similarity to those of Leonardo da Vinci. [From "The Huxley Papers (*2*, 34, 167 vo), courtesy of the Imperial College of Science and Technology]

But, a strong individualist, he never wished to be known as a mere advocate; he could not tolerate being considered simply as an appendage, still functioning actively but eventually to become vestigial, to Darwin. He had one great reservation that retarded his complete acceptance of natural selection as the *vera causa* of origination. In his first article written in support of Darwin's hypothesis, "Time and life" (*13*), Huxley pointed out that since artificial selection had not yet produced real species, there was no scientific ground for assuming that natural selection could do so. If all the varieties of pigeons could intermate freely, after centuries of selective breeding, Darwin's prime analogy fell flat. Darwin never failed to smart under this criticism, which was greedily snapped up by hostile reviewers. Huxley was, in fact, carping, demanding that the line of demarcation between varieties and species be drawn sharply, and neglecting the phenomenon of partial fertility among varieties produced by artificial selection.

But it was judicious to submerge dissension within the ranks in the face of the continual and vociferous blasts directed by the popular periodicals against the theory. Huxley followed his first article

on natural selection with a second, and then there smiled upon him that chance which many declared was Darwin's goddess. The regular reviewer of the *Times* admitted his incompetency to review the theory and asked Huxley to perform that function; Huxley did so gladly, but secretly. Darwin was overjoyed to find the *Times* supporting him, commenting to Huxley that "The old fogies will think the world will come to an end." Thus the first telling blow for Darwinism was struck in the pages of a conservative paper, probably achieving the result Huxley intended: to make "the educated mob" (*14*) reflect. The review in the *Times* preceded the dramatic meeting at Oxford in 1860, and from that date onward, the Darwinians took the offensive until, by the end of the century, Huxley himself was admonishing the evolutionists not to accept Darwinism on faith alone.

Throughout the 1860's and 1870's Huxley produced one essay after another, lectured in scores of places, and wrote a number of books, everything substantiating the theory of descent and dedicated to what he revered as his liege lady, science. Huxley was primarily an anatomist, doing major research on the pulmonary artery of the vertebrates, on cranial morphology, classification of bony fishes and of birds, compiling a general anatomical survey of the rodents. Close to 100 notebooks on these and related matters testify to the enormous amount of original work he did in helping to lay the foundations of modern biology (*15*).

He was rewarded almost yearly with various positions in the world of science: examiner in physiology and comparative anatomy in the University of London, then Fullerian professor of comparative anatomy at the Royal Institution, and later Hunterian professor at the Royal College of Surgeons. He was president of the Ethnological Society, of the Geological Society, of the British Association for the Advancement of Science, of the Royal Society; the first dean of the newly established Royal College of Science; a member of ten Royal Commissions investigating everything from salmon parasites to technical education; and editor or prime mover behind the inauguration of periodicals such as *Nature*.

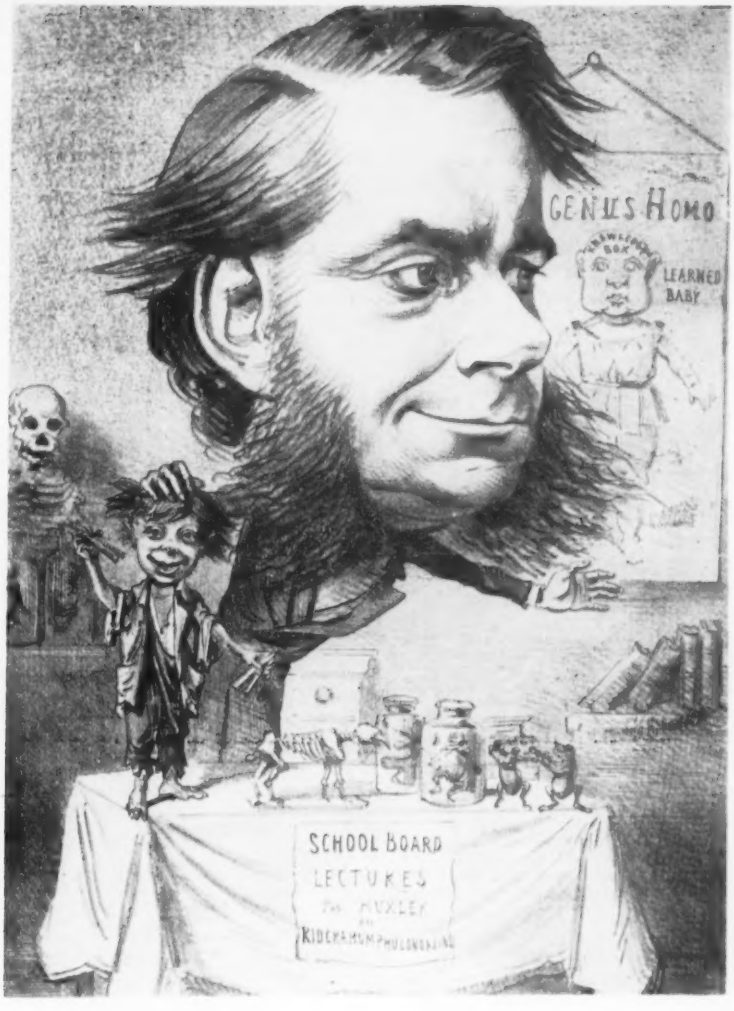
He was equally at home in the worlds of geology and biology. Darwin was met everywhere with "Oh, this is opposed to paleontology—or that is opposed to paleontology," as Huxley complained (*16*). It was the geologic record which, asserted some reviewers, Darwin had entirely set aside that either proved or disproved natural selection, and Huxley determined to show that geology supported Darwin. To his peers he lectured on homotaxis; to the working men he lectured on the more general facets of geology and paleontology, allowing to be published in 1862 a series of pamphlets on "Our knowledge of the causes of organic nature." These lectures had a wide sale, eliciting the envious reflection by Darwin: "What is the good of my writing a thundering big book, when everything is in this green little book so despicable for its size?" (*17*). Huxley would take a lump of coal, or a piece of chalk, or a stem of coral, in every case to demonstrate the antiquity of the earth and give to natural selection all the time it required.

A year before he was elected to the London School Board, which determined the educational procedures and standards of secondary schools in England for more than 70 years, Huxley lectured to school children at the London Institution, and later to women at South Kensington, on a subject he called "physiography." The lectures were popular, the book he later wrote had a large sale, and he set the pattern for subsequent works on physical geography. He wrote an introductory volume to, and had a great deal to do with the publication of, science primers. Huxley's primary goal in secondary education was to introduce into the schools the study of science, to win for biology, chemistry, and physics the place in education that was monopolized by Latin and literature; despite Matthew Arnold and satirical caricatures, he succeeded in realizing his ends in public, technical, and medical education.

Man

When, as Croonian lecturer in 1858, Huxley chose as his subject the vertebrate theory of the skull, he took the first step in a long advocacy of the theory of man's anthropoid descent. He opposed the Platonic notion that man had been created according to a divinely established plan, and he set out to prove that the skull was not merely a modified vertebra. The controversy between Huxley and Richard Owen started in the laboratory, but when in the spring of 1860 Huxley directly challenged Owen and then rebuked the Bishop of Oxford, it came into the public domain. Unlike Darwin, who diplomatically avoided saying anything about the ancestry of man, except for a brief and ominous warning that something might be done about man in a later work, Huxley's interest from first to last was not in natural selection but in human evolution. The question of questions for more than Victorian biology was: How far is man a part of animal creation? The answer that man had developed like other species and was in fact the descendant of an ape-like ancestor was repugnant. It was the anthropoid descent of man which most reviewers ridiculed in articles that were ostensibly against natural selection.

Having discovered that popular lecturing was one



Huxley's well-known views on a broader scientific education led some hasty critics to assume that he would proceed to stuff school children with such useless information as that noted on the tablecloth of this 1871 caricature, entitled "Huxley on Mountin' Kids." He did not do so, of course. Eminently successful as a member of the London School Board, he was instrumental in formulating a plan for elementary education which lasted for 70 years. [From "The Huxley Papers" (2, 79, 11), courtesy of the Imperial College of Science and Technology]

of the best means of clearing up matters in his own mind, Huxley lectured to working men on the relationship of man to the lower animals, and he achieved a unique success. "My working men stick by me wonderfully," he wrote to his wife, "the house being fuller than ever last night. By Friday evening," he added happily, "they will all be convinced that they are monkeys" (*18*). He delivered a similar series of lectures in Edinburgh, and the Philosophical Institute greeted with applause his unequivocal declaration that man had descended from a simian ancestor. Cheered by this expression of liberal opinion, Huxley went to work in earnest on something which would "astonish the natives," revising his lectures, investigating the newly discovered Neanderthal skull and other fossil remains of man, gathering information from various sources on structural similarities between men and apes.

Although he was strongly advised not to publish, he decided to brave all opposition. *Evidences as to Man's Place in Nature* was completed and published in 1863, 8 years before Darwin's *Descent of Man*; it not only prepared the way for Darwin's anthropological work much as Lyell's *Principles* had cut through catastrophism and left a clear road for biological uniformitarianism, but *Evidences as to Man's Place in Nature* was important in itself. Backed by anatomical evidences to which Owen shut his eyes, Huxley proved that the structural difference between a lemur and a gorilla was greater than that between a gorilla and a man. It was the first time this had been done. Man's glory could no longer depend on his unique possession of a hippocampus minor. Like his other works, Huxley's principal anthropological study was immensely successful, and, as a contemporary newspaper reported, was torn from the hands of booksellers as if it were a novel. The gorilla had been

This caricature, from the New York *Daily Graphic* (27 Sept. 1876), has below it the following verses:

Huxley Eikonoklastes

Grand in the light the sacred records throw
  Old Moses stands, a hero of all time—
  Lawgiver, prophet: on his form sublime
Wrought with his art great Michael Angelo.
And Milton, whose blind eyes with clearer ray
  Grand visions saw, and fixed with mighty pen,
  Unwielded yet by hands of newer men,
The vision of Creation's primal day—
Stands ever, and shall stand while Time shall be,
  A shadow of that God of whom he spake.
  Not thou, O Huxley! though thy frame should break,
Can'st harm these giants, hew thou mightily.
  Hold off! hold off! and go thy chosen way,
  Nor Moses with thy fictious Milton seek to slay.

Huxley, in attempting to avoid discourteous references to Genesis, employed "Paradise Lost" as the best statement of the biological catastrophism which he attacked in his New York lectures of 1876. [From "The Huxley Papers" (*2*, 79, 16), courtesy of the Imperial College of Science and Technology]

given that name as late as 1847; after *Man's Place*, it was a celebrated animal; many of the terms used in the book became famous, even being mentioned in Charles Kingsley's children's book *Water-Babies*.

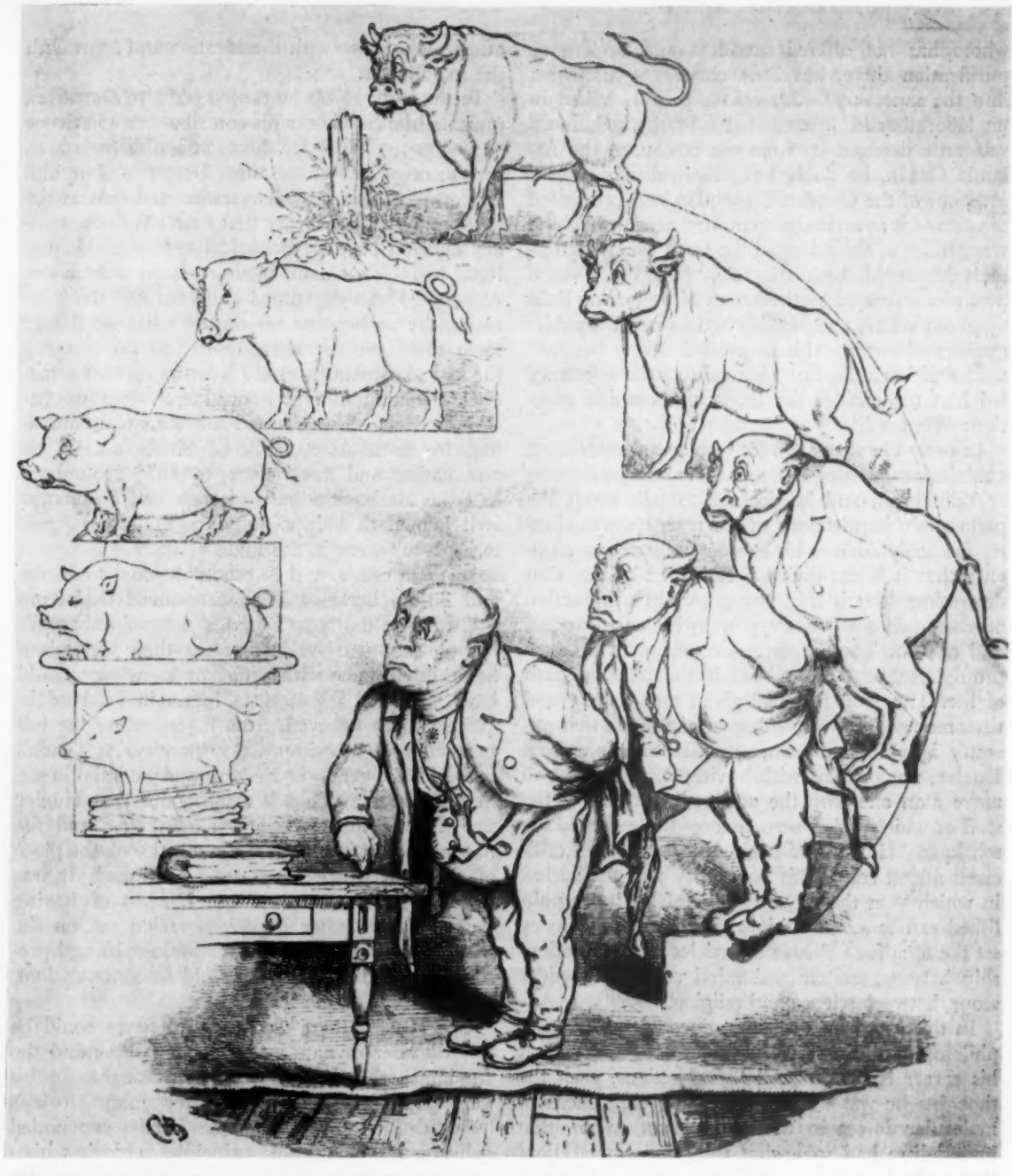
"As for me," Huxley wrote to a correspondent, summing up his contribution, "in part from force of circumstance and in part from inclination . . . I have played the part of something between maid of all work and gladiator general for Science" (*19*). "When people say *science* in England," ruefully admitted a hostile critic, "they mean a late article by Professor Huxley" (*20*). Huxley had not always been considered as the tail to Darwin's comet, trailing along as rapidly as, but lost in the glory of, Darwin's brilliance; in his era he received fame if not fortune for his original contributions to biology and, of greater significance, for his magnificent espousal of science and rationalism. In his own age a man lives less in the criticisms of intellectual journals than in the folklore of a people; what better comment could there be on the popular conception of Huxley than the following anecdote from an obituary notice? "The late Professor Huxley was so intimately acquainted with the properties of all the geological formations of England that, being one night belated, and not knowing where he was, he alighted from his horse, took up a clod of earth, and examined it. He immediately exclaimed, 'Uxbridge,' and proceeded on his journey" (*21*).

Philosophy and Religion

In 1885 Huxley retired from all his official functions, including the presidency of the Royal Society and an active professorship at the Royal College of Science, and turned with alacrity to a thorough examination of the theological assumptions of his age. Although he thought of his philosophic and religious writings as "fugitive work," he had, from the time he was a youth, been very interested in the metaphysical subjects that distressed Darwin. In his teenage notebook, entitled, German fashion, "Thoughts and doings," he had entered the quotations that caught his fancy—comments by Goethe, Novalis, and others to whom he was introduced by reading Carlyle. We can know matter only by its properties, he once wrote; we cannot find any absolute basis to substance; the only thing we can certainly know is that our thought exists. On some nights he would curl up in bed with Hutton's *Geology*; on other nights he would read philosophy or books on early Christianity. During the *Rattlesnake* cruise, he worried about his growing skepticism, his inability to hold onto the certainty of his religious training, and he determined to adhere to Goethe's dictum of *Thätige skepsis,* the active skepticism that strives to overcome itself but which, it should be added, in Huxley's case never did.

The extension of the scientific method to the realms of philosophy and religion was characteristic of John Tyndall, W. K. Clifford, and other 19th-century scientists who, overwhelmed by the rapid advancement of knowledge and material comforts, attempted to apply to nonscientific modes of thought the discipline that had proved so efficacious in the laboratory. Essentially, they all wished to establish a monistic view of the world, embracing in one vast scheme mentality, morality, and the flux of atoms.

Huxley, during the sleepless nights caused by his



The origin of species by means of natural selection and especially its derivative notion of the anthropoid ancestry of man were subjected to much ridicule in mid-Victorian times. Some of this ridicule was malicious and intemperate; much of it, however, was in the same category as this burlesque which appeared in the *Illustrated Times* and was entitled "The Origin of Species, dedicated by natural selection to Dr. Charles Darwin. No. 1—Like a bull at a gate. (Drawn by C. H. Bennett)." [From "The Huxley Papers" (*2*, 79, 15) courtesy of the Imperial College of Science and Technology]

dyspepsia, checked against his own notions the sayings of the great philosophers, always recalling the implications of his scientific research in order to provide the necessary ballast to his flights of philosophic fancy. There was for him a very close connection between the worlds of science and metaphysics. "In truth," he wrote, "the laboratory is the fore-court of the temple of philosophy; and

whoso has not offered sacrifices and undergone purification there, has little chance of admission into the sanctuary" (*22*, vol. 6, p. 61). When in his laboratory he investigated a lumpy, gelatinous substance dredged up from the bottom of the Atlantic Ocean, he dubbed it "Bathybius haeckelii" in honor of the German Darwinian and proceeded to write of it as an undifferentiated organism which was similar to the primeval life from which all animals descended. Unfortunately, "Bathybius" was a precipitate formed by the action of preserving fluid upon sea water, and Huxley had to make a public apology disowning this creature halfway between mud and bacteria. But his work on the substance led him to consider the larger, philosophic question: What is life?

In early October 1868 he received a letter from a minister requesting him to initiate Sunday lectures at Edinburgh, and he decided to talk about the philosophic implications of his recent work. Huxley fearlessly advised his Scotch Presbyterian audience that it is not divine breath, or vitalism, that determines life; it is rather a certain conjunction of chemicals such as oxygen, hydrogen, nitrogen, and carbon. These elements combine to produce protoplasm, and protoplasm is the physical basis of life. The geologists had given man a long and tiresome ancestry, the biologists had made that ancestry ignoble and now, complained the critics, Huxley, not content with having done his best to make man one with the ape, reduced him to the stuff of which a slug was composed. He earned the sobriquet "Huxley the Moleculite," but such criticisms added zest to his popularity and the review in which "On the physical basis of life" was published ran to seven editions. Furthermore, Huxley set the tone for a deluge of articles on the relationship between matter and mind and, on a wider scope, between science and religion.

In this essay, Huxley's first devoted primarily to philosophy, the position he maintained throughout his career is evident. All living actions, even the thoughts he was uttering, were the expressions of molecular forces in the protoplasm. Aware that materialism had somewhat the same connotations then as had the Reign of Terror earlier in the century, he expressly denied being a materialist. He explained that he simply used materialistic terminology because it was a necessary tool for the expression of scientific concepts, but that a materialistic philosophy involved grave error. Going back to the jottings in his notebook, he pointed out that everything we know is in our own minds and that matter and spirit are "but the names for the imaginary substrata of groups of natural phenomena" (*22*, vol. 1, p. 160). Huxley was being disingenuous, attempting to flee with the idealists and hunt with the materialists.

In the early 1870's he turned often to Descartes, praising him highly for his contributions to science as well as to philosophy. More or less disregarding, for the exigencies of the time, Descartes' *âme* and Descartes' dualism, Huxley resurrected him as the propounder of the theory that man's volition actually depends on the mechanical actions of his material body—that man, in short, is an automaton. Although Huxley qualified and confused this conclusion by noting that we can do what we like in some cases (unspecified), there was no escaping the logical consequences of his assurance that someday we would find a mechanical equivalent for consciousness as we have found a mechanical equivalent for heat. As a result of Huxley's talks on automatism and materialism, by 1875 protoplasm and the mechanical basis of man had become as well known as "hippocampus minor" and "posterior lobe" were in the middle 1860's.

In these essays, and in others devoted to Hume and Bishop Berkeley, Huxley removed God from the universe and substituted a deterministic philosophy that was no less severe than Calvinism. Some intelligence with sufficient knowledge could have predicted the state of fauna in England in 1869, Huxley believed, from investigating the full properties of the primordial nebulosity. As Tyndall had said, the genius of Newton was potential in the fires of the sun. Thus it came about that Huxley saw in Darwinism a "higher teleology," and the natural law which Descartes extolled took the place of the God which Descartes worshipped. It was difficult for critics to accuse Darwin of having deified chance after Huxley pounded out on the anvil of science a deterministic philosophy and presented it as the shoe that would fit anyone's foot, the scientist's or the religionist's.

For Huxley there was not and never could be any disorder in nature—this was to his mind the fundamental axiom of scientific thought. In his very popular *Hume,* written for John Morley's "English Men of Letters" series, Huxley expounded fully on his philosophic principles, enjoying himself immensely in the chapter on miracles. Briefly, there were no such things. Nature could not be violated; if it be true that a man rose from death, then our notions of death must be revised to fit in with what actually occurred. Huxley did not find any cogent evidence to believe in such a miracle, and in 1876 read a paper to the Metaphysical Society in which he tried to prove that Jesus had not really been dead at the time of his entombment, that—and Huxley was specific—rigor mortis and general putrefaction had not taken place (*23*).

It was at a meeting of this wonderful society, in which were many representatives of believers and unbelievers, from a Roman Catholic cardinal to confirmed atheists, that Huxley decided to give a name to the contradictions which were not only in his own philosophy but, apparently, in the world itself. Like the fox in the fable, he lacked a tail, and in order to be able to prance about as proudly as his fellows he invented the term *agnosticism* to describe his philosophic position. The word was taken up by the *Spectator* and immediately became current coin, but since it has been counterfeited by other thinkers, perhaps it would be well to explain what Huxley meant by it. He himself defined the term a number of times, and while he did not always say it meant the same thing, it is clear that he did not equate it with utter and unmitigated ignorance, nor did he mean it to represent Spencer's Unknowable Noumenon, though Spencer adopted the term.

For Huxley, agnosticism was the essence of science. It was a confession of ignorance about things we do not, and perhaps cannot, know, things such as the existence of God or the immortal soul; but it was, on the other hand, a confession of faith about things we do know. These, such as the protoplasmic basis of life, we can believe in, accepting the notion as a working hypothesis which fits in well with the rest of our knowledge, a positive affirmation that is good for the present but possibly will not hold good for the future when new investigations result in a further extension of knowledge. Huxley was aware of the liabilities attaching to an essentially negative philosophy and of the fact that most people would be dissatisfied with it, but he held fast to his belief that it was immoral, as well as unscientific, to place belief in things that have not been proved. Agnosticism was a topical challenge to the "gnosis" of Cardinal Manning and Samuel Wilberforce.

Someone reading Huxley's earliest essays and knowing the temper of the times could have predicted with some accuracy that from science he would turn to philosophy and then finally to religion and ethics. He saw the obvious religious implications of Darwinism and believed that there was no point at which science and theology could meet. Here he inserted a caveat: science and religion were Siamese twins, and the death of each would result from their separation. Since religion, taken in the Carlylean sense, excluded the supernatural, he could say without self-contradiction that science must be religious and that religion "flourishes in exact proportion to the scientific depth and firmness of its basis" (*24*). Religion was the inner yearning for knowledge of the starry heavens above and the moral life within; it was not faith in the idolatrous mythology of primitive peoples. And Huxley, in his capacity of maid-of-all-work for science, determined to remove from the human mind the white corpuscles of sacerdotalism, with its false science and its deleterious priesthood. This process he called "episcophagy," but it was not only bishops that he ate.

In 1876 he was invited to the United States to read the opening address at the new Johns Hopkins University, and he was also to lecture in New York City on evolution. Contrasting to Milton's account of the creation the findings of biology and geology, he insisted that the Scriptures cannot be taken as a valid scientific text. Ten years later, suffering from a severe attack of his blue devils, Huxley read an article written by William Gladstone in which the prime minister suggested that modern science substantiated the order of creation in Genesis. Huxley's bile was stirred, his liver set right, and the curative effects of a "Gladstonian dose" became famous in the Huxley household. He offered a flat denial to Gladstone, who, at a disadvantage in an argument about paleontology, shifted his ground. Soon Huxley and Gladstone were debating the merits of Jesus' driving spirits from men into pigs and then destroying the latter. During the time he was turning to biblical exegesis, Huxley was possessed by a writing demon, telling Hooker: "Providence has, I believe, specially devolved on Gladstone . . . the function of keeping ''ome 'appy' for me. I really can't give up tormenting *ces drôles*" (*25*). Genesis, the Gadarene pig episode, the Noachian deluge—to each of these controversies in the higher criticism, Huxley brought to bear the knowledge accumulated in three decades of teaching and lecturing on science. While entertaining, he instructed; while instructing, he moralized.

He believed firmly that the man of science not only had a free pass into philosophy, but that he was better qualified than the theologian to discuss questions of morality. Science teaches a "fanaticism of veracity" which is a healthy attitude to be applied to everyday behavior, while, presumably, theology teaches subjection to authority and not to truth. To believe without evidence is more than a crime; it is a sin, an immoral act against one's own nature. The Darwinian hypothesis itself could not be adopted as a moral code, because there is a fundamental contradiction between the cosmic process described by that hypothesis and the contrary process, the ethical, adopted by human societies. "No doubt," he once said, "crib-biting, nurse-biting and original sin in general are all strictly deducible from Darwinian principles" (*26*). But if we cannot find a suitable moral code in the

imitation of brute behavior, we can obey that new decalog that commends us not to be proud or revengeful; not to be afraid of admitting unpleasant truths or of opposing vested authority; not to revile others for opinions honestly held or to blind ourselves to the light of knowledge; not to cant, lie, or wander aimlessly about in careless speculation; and not to believe without evidence.

The New Reformation

"If there is anything I thank the Gods for (I am not sure there is, for as the old woman said when reminded of the goodness of Providence—'Ah but he takes it out of me in the corns') it is a wide diversity of tastes. Barred from scientific work, I should be miserable, if there were not heaps of other topics that interest me, from Gadarene pigs and Gladstonian psychology upwards. No one who has lived in the world as long as you and I have, can entertain the pious delusion that it is engineered upon principles of benevolence. . . .

"But for all that, the cosmos remains always beautiful and profoundly interesting in every corner —and if I had as many lives as a cat I would leave no corner unexplored" (*27*).

It was this catholicity of interests, this vital and liberal love of knowledge, that was the characteristic note of Huxley's life and that enabled him to play so significant a role in effecting what he was fond of calling the new reformation. By 1894 he had done his work. Once again he was in the Sheldonian Theatre at Oxford, this time not to enter battle but to take the laurels of victory when the Darwinian hypothesis was recognized as the greatest contribution to Victorian biology. Impressive in his regal robes of doctor of civil law, a man whose life had been lived fully and well, who had made his mark and had helped to turn Western thought in a new direction, he recalled to many of the older members in his audience a similar scene enacted almost 30 years before on the same platform. A year later, when he completed reading a book condemning scientific naturalism, he roused himself from retirement at Hodeslea, from cultivating his garden, and he was once again ready to rebuke the unsanctified. But influenza aggravated by bronchitis and weakening of the kidneys broke down even his redoubtable strength, and he was unable to complete a long article defending the honor of his liege lady. For 4 months he lingered on, suffering severely but relying for solace upon his philosophy of grin and bear it, his quick and ironic sense of humor, and on the afternoon of 29 June he died as he had wished to, in the midst of a controversy dedicated to the new reformation.

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Genetics in Animal Breeding

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The author is professor of poultry husbandry and geneticist in the Agricultural Experiment Station of the University of California, Berkeley. Dr. Lerner's major interest is in population genetics in relation to animal improvement and evolution. This article is abridged from a lecture delivered before the Japan Society for Zootechnical Science at a meeting in Tokyo on 11 September 1956.

SELECTIVE breeding of animals for the purpose of improving their economic qualities had been practiced long before there was any clear understanding of the bases of such operations. It is impossible to say when man first became aware that descendants resemble their ancestors more than might be expected by chance, or when this phenomenon was first attributed, at least in part, to organic inheritance. It is certain that more than 2000 years elapsed between the earliest utilization of this idea for practical purposes and the discovery of the fundamental principles underlying the physical basis of hereditary transmission. Much of the breeding progress by pre-Darwinian breeders was based on sheer guesswork and was impeded by many fallacies, such as those regarding maternal impression, telegony, and prepotence based on physical vigor of the parent in question. Nevertheless, the master-breeders of the 18th and early 19th centuries were doubtless successful in achieving their goals without possessing the facts of formal genetics.

Yet, the methods which proved serviceable in pre-Mendelian days are definitely limited in their potentialities. In the first place, the early breeders were practitioners of an art rather than of a science. This means that intuition and personal experience were the most important ingredients of their prescriptions for success. Since no objective criteria of genetic worth existed, no valid generalizations about optimum breeding procedures could be made. The recipes advanced for genetic progress were most often based on percentage of blood, linebreeding, and other such vaguely defined schemes. There were many "secrets," consisting of a successful breeder's schemes of selection, mating, feeding, and management, which he happened to have discovered largely by chance (since there was no controlled experimentation), and which could prove to be dismal failures at the hands of another. In other words, inefficiency and complete lack of predictability of results were characteristic of pre-Mendelian days. Indeed, it is possible that it was selection between breeders, rather than the selection exercised by any breeder on his own flocks or herds, that played the decisive role in determining the probability of long-range success of a breed.

Another fact which needs to be mentioned particularly in application to creators of breeds is that their goals related to characters of reasonably high heritability. Color, form, and body size, as a rule, show a much higher correlation between genotype and phenotype than such traits as yield of milk, eggs, and wool, or litter size. That is to say, confusion between the phenotype, the appearance of an animal, and the genotype, its hereditary endowment, is a less serious handicap when breeding objectives are centered on highly heritable characters than when selection is directed toward traits more readily subject to modification by random environmental differences between individuals. Today, with few exceptions, the economic value of animals depends less on appearance than on performance, less on gross anatomy and more on physiology. Visual inspection of individuals must then, at best, play an ancillary role to other criteria. To combine several of these into an index of merit requires quantitative and objective methods of measurement. Standards of comparison based on unbiased averages are needed; indiscriminate culling during periods of performance-testing becomes inadvisable; genotype-environment correlations have to be controlled. These and many other aspects of breeding policy (including some strictly economic ones) have made pre-Mendelian attitudes and methods unusable, even though in their own time they may have served well.

With the rediscovery of Mendel's laws the opportunity arose to replace purely empirical bases and wildly speculative hypotheses of breeding practice by verifiable theoretical foundations. Once the basic mechanics of hereditary transmission were understood, the principles of utilizing them could be developed without dependence on personal experience or on such special individual gifts as the ability to evaluate the worth of animals—an endowment necessary when improvement is based on subjective judgments. Of course, this transforma-

tion could not have been forged solely from acquaintance with Mendelian principles; it also required the notion of applying mensuration, essentially a contribution of biometry, to breeding. But Mendelian and biometrical principles, for a while assumed to be antagonistic, were in the long run complementary in their effect on breeding.

It was at the beginning of the present century that the possibility that breeding might eventually be an altogether scientifically directed enterprise became more than a visionary idea. The full fruition of this possibility has, of course, by no means arrived. What is called "stock sense" may still play a considerable role with some classes of livestock, though, in the huge poultry-breeding establishments, for instance, the mere volume of operation precludes the possibility of any weight being given, in selection, to the subjective evaluation of appearance by a single person. The discovery of the physical basis of inheritance, combined with the introduction of measurement as a fundamental selection tool, was necessary for the formulation of objective procedures, clearly a first essential for exactness. Of course, objectivity is only the minimum requirement. All it means is that the procedures used are consistent and repeatable. Objectivity per se does not guarantee that the results obtained will be those wanted. Before this desideratum could be even approached in animal improvement, population genetics had to come into existence.

An even more important effect of the new knowledge on ideas about breeding should be mentioned at this point. It was the consequence of the distinction that Mendelism made between the concepts of phenotype and genotype. True enough, the early Mendelians emphasized only gene interaction as the source of difference between appearance and heredity. The environmental components of phenotypic variation which also contribute to this difference must have been assumed by the inventors of the progeny test and were demonstrated experimentally very early in the history of genetics. But the full practical employment of genotype-phenotype distinctness in animal breeding also had to await the time when population genetics entered the scene.

Advent of Population Genetics

What did this approach add to the state of animal breeding? Why is it to be considered a progressive one? What was its main impact on research and on practice? In answering these questions the fact that population genetics came into existence from the synthesis of the Mendelian and the biometrical schools should be stressed. Even in evolutionary studies on single gene differentials, the development of population genetics was based not only on the understanding of the mechanics of inheritance and on the introduction of experimental methods but even more on a quantitative approach. In breeding application the latter was paramount.

What happened was that breeding came to be viewed as a statistical process; that the algebra of Mendelian inheritance was extended to a large number of loci; that analysis of variance led to ascertainment (in a very rough way at first) of the relative contributions of genetic and environmental sources of variability; that analysis of covariance allowed the development of selection indexes. Above all, the most important step forward was the introduction of what may best be called the *operational* approach.

There are many possible definitions of this point of view. Usually, in practical matters, the emphasis is on the comparison of expected returns with expected costs. Thus, if a certain procedure promises to increase the yield of some product of interest to the breeder, the operational approach requires that, instead of adopting it blindly, he first compute whether the extra costs are not greater than the extra returns expected. This is obviously an elementary business practice but, as a matter of fact, I am sure that few if any breeders were governed by such considerations until very recently.

Actually, I would like to use operationalism in a somewhat broader way. More particularly, it is the attitude which, for the first time in the more than 2000-year history of animal breeding, permitted the choice of breeding procedure to become not an arbitrarily settled issue, nor one based on empirical experience (obviously not always a practical possibility), but on a rational comparison of results expected from a series of alternatives. I do not wish to imply that we have reached a stage where any problem facing a breeder can be solved with assurance that the correct answer will be forthcoming by following some computation procedure in, let us say, 95 percent of cases. This may be an eventual goal. It is still far away. Rather, what I mean is that, while the decisions the breeder makes may be often in error because of lack of adequate information, there is an advance over the previous stage of knowledge in that everybody in possession of a given set of data now can arrive at precisely the same answer.

Thus in pre-Mendelian days each breeder practiced his own system, which by and large was not repeatable by others. In the early days of Mendelism, objective (that is, repeatable) systems of selection and mating appeared. Now, in the era of population genetics the possibility of judging whether one objective system is better than another has

come about. This is to say that not only the system but the predictions about its consequences have become repeatable. Clearly, the next step necessary is one permitting not only the same answers to be arrived at by different people but assurance that the answer has a high probability of being the correct one.

I think that it is fair to say that in some situations we have already arrived at this point. For example, it can be demonstrated that, if improvement in the annual number of eggs laid by a large freely interbreeding population of chickens not previously selected for this trait is desired, family selection based on the performance of birds under 1 year old will be more efficient than mass selection of 2-year-old birds. Similarly, I venture to predict that, under the same circumstances, it is not only less expensive but also more profitable to select for increased egg weight on the basis of individual records rather than on that of progeny tests of females.

There are, however, other situations where we cannot be as confident regarding the outcome of predictions arrived at by an analysis of a breeding system proposed. This, we may hope, may be remedied in time. The main point is that objective evaluation of breeding techniques has become possible. This step was, probably, comparable, in its significance and potential consequences to animal breeding, to the one made when the distinction between phenotype and genotype was clarified.

Principles of Population Genetics

Now what exactly were the discoveries or the formulations of population genetics responsible for this advance in animal breeding techniques? I have already said that they were rooted, on the one hand, in Mendelism—the principles of particulate inheritance—and, on the other, in biometry—the techniques of quantitative analysis of biological data. The synthesis of the two, spearheaded by the theoretical work of Fisher and by the combined theoretical and experimental studies of Wright, formed the foundation on which subsequent investigators of animal breeding built. In the United States, Lush has been the outstanding pioneer and teacher in this field. A strong school which originated in the U.S.S.R. under Serebrovsky unfortunately failed to fulfill its promise when the Lysenko influence stifled the scientific approach to genetics. Perhaps the recent changes in Soviet policy will revive this originally very promising development. In Britain, after World War II, younger investigators (for example, Alan Robertson) pursued vigorously the development of the quantitative theory of animal breeding. Elsewhere, centers of research in this field gradually came into being, so that Australia, Sweden, Switzerland, and other countries are now beginning to make significant contributions to the subject.

It is not my intention to review these contributions even in very broad terms. Rather, I would prefer to illustrate my thesis by some general statements. Hence, I shall not credit any individual or institution with specific discoveries; but let it be understood that the formulation, deduction, and experimental verification of the principles mentioned were the work of many men. I should, however, like to make particular note of the fact that by no means all of them were interested in animal improvement. Subtle as it may have been, the influence of students of plant breeding, of experimental evolutionists, of statisticians, and of others in making population genetics applicable to animal breeding was inestimable. It is the work in pure biology, and in particular the branch of it devoted to the elucidation of evolutionary processes, that underlies the significant advances made in our efforts along economically important lines.

Now, to be more specific, which basic concepts of population genetics are of interest to students of animal breeding? No exhaustive treatment of this question is possible in a brief space. However, rather than merely list a greater number of points without explaining their significance, I have singled out an even half-dozen for particular consideration.

1) *Partitioning of phenotypic variance.* The concept that the phenotype may be viewed as a linear combination of genotype and environment led to the possibility of quantifying the relative contributions of genetic and nongenetic sources to the phenotypic variance. The proportion of the total variation which can be attributed to additively genetic differences between individuals, known as the degree of heritability, has become a parameter of fundamental importance in evaluating selection plans. Additive heritability reflects that fraction of the superiority of animals selected to be parents of the next generation which is transmissible to their offspring. It is basically a measure of the accuracy with which good genotypes can be identified from phenotypic observation. Effective heritability can, of course, be computed for any criterion of selection, whether individual or family, whether direct or indirect, and whether or not indexes utilizing auxiliary information about traits of no economic value are used. Clearly, the methods of computing heritability must occupy a place of honor among the contributions that population genetics has made to breeding.

Perhaps some words of caution are needed. They refer to a common tendency to trust heritability determinations more than they should be trusted.

There are many reasons why interpretations of values of this constant have to be made very carefully. Thus, it is possible that nonlinear interactions between genotype and environment exist. Correlation between these two sources of variation must also be looked for and eliminated, preferably by arranging for randomness of environment of the genotypes tested. Inbreeding may affect the magnitude of the estimates made. Nonadditiveness of genes may sometimes increase the computed heritabilities, when they are based on covariance between close relatives. Existence of maternal effects can, on occasion, be overlooked and lead to erroneous conclusions. Beyond all these difficulties, many of which care in testing procedure and in statistical analysis will obviate, there are others for which we do not understand the reasons. In fact, though it is fair to say that the heritability of traits in unimproved populations does have considerable validity as a tool for comparing different breeding procedures, we must also admit that in populations which have already been intensively selected for some given trait, heritability estimates do not appear to be very reliable for further prediction of gains. The problem is complicated even more by the fact that the sampling distribution of the different estimates of heritability is only now beginning to be studied. This, incidentally, is one area of population genetics which calls for more experimental and theoretical work.

2) *Prediction of gains.* The degree of heritability does not, by itself, provide sufficient information for decisions involving choice between alternative mating schemes. At first it was considered that the expected gain per generation could be computed as the product of heritability (that is, selection accuracy) and the selection differential (that is, the superiority over their own generation of the animals chosen for reproduction). Some refinements had to be introduced in this formulation before very long. For instance, in cases where natural selection opposes the direction of artificial selection, distinction between the differential attempted and that realized had to be made. Proper weighting based on the relative number of offspring actually under test in the next generation must thus be applied to the superiority value contributed by each parent to the total selection differential.

Even more momentous was the discovery that alternative schemes of selection may rank in different order with respect to gain per unit time than they do for gain per generation. Hence the formula, "expected gain equals accuracy times intensity of selection," had to be modified by adding a denominator to this expression: the average interval between generations, or the average age of parents.

With this procedure it became possible to demonstrate that, under many circumstances, progeny testing, which increases the average interval between generations, may be inefficient as compared with sib testing. Another and more specific example, first established theoretically and then demonstrated experimentally, is given by the use of partial versus full information on egg production in poultry. Here, if selection is made on the basis of the full first-year record, the minimum interval between generations in commercial breeding practice is 2 years. If, however, only winter production is used as the criterion of selection for the desired trait of annual production, accuracy is reduced to three-quarters of that attained in the first case, while at the same time the denominator in the prediction equation is halved. The net result is, then, a fair advantage of the latter scheme over the former. This example is still a source of surprise to many, and at first sight it does seem strange that selection on a basis of less information is to be preferred to that on a basis of more. Yet, understanding of the operational attitude clears up the ostensible paradox.

There are, of course, difficulties and complexities beyond those already enumerated. But empirical tests of at least some of the conclusions arrived at from prediction equations are being made, and, by and large, the results are encouraging, at least (as already noted) in the early generations of selection.

3) *Consequences of mating systems.* Chronologically speaking, the first concrete contribution to animal breeding made by population genetics was in the definition and quantification of the formal genetic (as against biological) effects of different mating systems. Thus, instead of the vague terms, *linebred, slightly inbred, mating like to like,* and so forth, coefficients of inbreeding, of relationship, of assortment, and so on, came into being. I need not labor the obvious facts that such quantification made it possible to study more precisely the biological consequences of inbreeding, that comparison between the results of various nonsystematic inbreeding schemes become feasible, that mating systems designed to maintain the maximum possible heterozygosity in closed populations could now be designed, or many others.

I am not sure that the rise of techniques for producing heterosis by crossing inbred lines is completely attributable to this development (hybrid corn breeding, of course, originated earlier), but it is clear that their efficiency must depend on it to a considerable degree. For instance, the evaluation of the possible worth of a potential parent in improving stock can now be made, not only on the basis of the animal's own performance, or that of its ancestors or collateral relatives, but also, in cer-

tain instances, on its inbreeding coefficient and its relation to prospective mates. One example is the use of an inbred sire for topcrossing. This may be a scheme which is relatively unimportant. It is noted here, in preference to the more obvious examples, to illustrate how widespread is the utility of the discovery that an animal of a very poor phenotype may have great possibilities as a parent if its apparent lack of merit is a consequence of the breeding system which has produced it and not of the absence of plus genes for the trait under selection.

4) *Partitioning of genetic variance.* So far we have considered genetic variance largely of the additive type. There is usually present, also, nonadditive genetic variation which leads to different consequences for selection practice depending on its exact nature.

The basic varieties of nonadditive gene action (and reference here is, of course, to action on an arbitrary quantitative phenotypic scale rather than to that on the primary biochemical level) are dominance and epistasis or, respectively, the interaction between alleles at a single locus and that between nonallelic genes. One of the more recent advances in the theory of population genetics has opened up possibilities of estimation of the amounts of each type of interaction. At the moment, application of the techniques elaborated is feasible only in plants, where self-fertilization can occur and where experiments can be performed on a scale needed to obtain reliable results. Their eventual use in animal breeding is, of course, not precluded.

It should be emphasized that conclusions about the prevalence of different types of nonadditiveness are not directly transferable from one plant species to another, let alone from, let us say, corn to cattle. Even within the same species different populations with different genetic biographies may be found to behave in an unlike fashion. Yet, should the new estimating techniques turn out to be useful in plants, it is clearly possible that modifications of them suitable for analysis of, and application to, animal material may be devised.

5) *Partitioning of phenotypic correlations.* The invention of methods to separate the covariance between phenotypic traits into the part due to a genetic correlation between them (usually pleiotropy, linkage, or common introduction) and the part due to the fact that they share a common environment was another step of great significance to breeding. It permitted proper use of other criteria of selection in addition to, or in preference to, the trait forming the object of improvement. It led to the possibility of estimating expected changes in characters not under direct selection. It was basic to the formulation of the principle of total score selection, in which appropriate weight is assigned to each of several characters taken into account in selection.

Especially in this last connection it became important to distinguish between economic worth and biological significance, so that selection for multiple objectives could have a truly operational basis. Selection indexes can now be constructed to pay the right amount of attention both to heritability and the monetary value of each unit gain in a trait. Thus, not only can alternative schemes of selection be formulated rationally, but the most efficient form of each can be identified. Although the theory of selection indexes is not more than 20 years old, it has already received application in many classes of livestock. Indeed, there are examples of commercial operation in which the elaborateness of indexes employed has reached a stage where electronic computers have to be used in their calculation. It should, however, be noted that the estimation of genetic correlations utilized in these indexes is beset by even greater pitfalls than that of heritability. Their sampling variation is also not clearly understood, and hence little judgment of their reliability is as yet possible.

6) *Balance.* As the last concept, I would like to mention the idea of phenotypic and genetic balance on the individual and on the population levels. The general notion that any surviving individual or population must possess adequate internal resources to cope with the usually fluctuating and irregular environmental stimuli to which it is always exposed, is, of course, not new. It is only recently, however, that the genetic aspects of this principle have been explored. Thus, it has been suggested that the individual maintains a balanced state in the face of the varying external pressures by relying on genetically controlled processes of homeostasis. Similarly, it has been proposed to view such mechanisms as the variation in selection coefficients as a function of gene frequencies, and other possible devices, as, for instance, balancing mutation against recombination rates or the regulation of heritability values, as being due to natural selection for population homeostasis.

Should the processes on the individual and the population levels be independent of each other, one would probably have to postulate the existence of interpopulation selection to account for the latter. On the other hand, if it could be shown that population homeostasis is a by-product of selective pressures operating on individuals, ordinary Darwinian selection might account for at least some features of it. In any case, this general notion has a series of consequences to breeding practice which may have far-reaching repercussions. For example, if intensive selection for a metrical extreme can be

applied only at the cost of losses in reproductive fitness, the ideal breeding system in short-range terms is probably not the best one for a long pull. (There are also other reasons why this may be true, such as genotype-environment interaction.) Perhaps milder selection, or intermittent suspension of selection, or occasional mass mating, or multiple-criterion selection based on an index for combining ability and for fitness, or some other scheme, may be preferable to the ones currently in wide use.

The Future

I think that this brief review of six points among many possible ones gives some idea of the effects that population genetics has had on our thinking about breeding problems. Yet the applications of the subject to actual procedures in the field are only in their infancy. In the past it has been common for practice in animal improvement to be ahead of theory. I am not sure that this is true any longer, at least in the case of the larger animals, though in poultry it still may be. But in the latter instance, practice now is rapidly passing into the hands of academically trained geneticists who are relying more and more on knowledge of the sort described in this article, and less on tradition. Thus deeds and thoughts are converging rapidly.

In general, the difficulty is that the validity of much of the theory can be established only by actual tests in the field. The cost and the time required for such experiments with large animals are very likely prohibitive. Hence, there is considerable uncertainty about many things that some population geneticists often take for granted. It is true that for a number of simple cases we can make predictions that will be borne out. But prediction without full understanding is not enough, for one can never tell when accuracy will break down, and if it does, why. The current experimental efforts of population geneticists must then turn to a search for understanding, not only of the statistical bases of character transmission and expression, but of their physiological bases as well. Full comprehension of the inheritance of quantitative traits and their genetic manipulation cannot be obtained otherwise. As an example, adequate methods of breaking through plateaus reached by improved populations will have to be based on knowledge of the reasons why advances have ceased.

What we must then look forward to are studies of gene action, descriptions of the paths from the primary gene products to the characters, investigations of the role in the animal's life-cycle of such biological variation as, for example, is represented by blood antigens, inquiries into the genetics of endocrine processes, and so forth. The emphasis on research of primarily statistical nature, important as it has been, should be somewhat redressed now, though further refinement and, at the same time, simplification of the mathematical techniques usable in animal improvement are called for.

In brief, the work in population genetics must now proceed in a coordinated fashion on the theoretical, the experimental, the descriptive, and the applied fronts. We have made the first important advance of introducing quantification into animal breeding procedures. This is a base which is indispensable for scientific progress. We may eventually have to discard most of our current models. We may possibly find that no general solutions can be reached for all classes of livestock and all characters at all levels of improvement. These are not serious matters in the long run, but they are of vital significance to any individual breeder who attempts to follow our advice. Hence, we must be sure that our specific recommendations are made in a spirit of tentativeness. We can do more harm than good to the cause of genetics, and to animal improvement, by being overly dogmatic at this stage. Flexibility of approach to different populations and to the same population at different times is needed. This obviously means continued exercise of some subjective judgment.

I note this fact particularly because, after all that I have said about the changes in breeding methods brought about by population genetics, I still wish to stress the thought that it is the potentialities of this science, rather than what it has already contributed, that are important. Our present notions about the various techniques may be shown to be in error, but the general idea of a rational, objective, quantitative, and operational approach, which I believe has flowered with the introduction of population genetics to the applied field, will remain as a permanent contribution to animal breeding.

When Is Human Behavior Predetermined?

EDWIN G. BORING

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WHEN is human behavior predetermined? Is man free to choose? sometimes? always? in respect of everything? May he thus by choice control his own individual destiny? This is surely what most men believe most of the time. The scientist, on the other hand—because the business of science is the study of causes and their effects—keeps insisting that any action of man, if we but knew enough, could be referred to its causes; that the explanation of all human behavior lies in the ancestral genes of the behaving person, in his past experience, and in the various accidents that have happened to him since he was conceived. On which side does truth lie? Is man quite free to think as he will or are his beliefs but a reflection of the climate of fact and opinion that envelops him, and of the circumstances that belong to the century, the country, and the family in which he lives?

This problem is not made easier when we realize that man's belief that he is free may itself be predetermined. The belief in freedom could be man's great delusion—nearly, if not quite, immutable. It is conceivable, you see, that there could be a society of talking robots, designed so that they continue to interact one with another in accordance with the principles on which they have been constructed, all of them chattering the while about their behavior in words that imply that each is free to choose whatever he does; that each, choosing freely, thus becomes responsible for his own conduct—a society of robots in which everyone asserts his own freedom for the excellent reason that he is *not* free to deny it.

We keep thinking, representatives of mankind that we are, that the integrity of each of us is so great that our assurances and convictions are at least partially self-validating; that our sense of certainty, even though it may waver, must at the very least tend to point toward truth. But what if delusion has been designed into us? What if the robot residents of some psychologist-designed utopia have been constructed so as to believe in falsehood and never to know it, the truth of their basic determinism being carefully hidden from them behind barriers of rationalizations to which assurance and conviction are firmly fastened? What are we to say in the face of this possibility? Biology offers us no protection against it, for there is always the possibility that survival can be favored by delusion, and that wisdom may on occasion be, if not lethal, at least not maximally helpful. In this respect man finds himself caught in an egocentric predicament, unable to grasp the standard by which he can tell reason from rationalization. What is he to do? What should we do?

This is no new problem, but it has recently received a new importance, because the development of the behavioral sciences has shown how the actions of animals and men can be controlled in greater degree than had formerly been possible, and even more, I should say, because the totalitarian countries, with their brain-washings and their forced self-accusations, have shown that man's integrity—the citadel of his freedom—can be invaded, and man's opinion, faith, and conscience enslaved. Indeed, the sense of freedom could be turning out to be man's great delusion. Is it? How do you answer a question like that?

There is, I believe, an answer, for that is what this paper is about; but first let us see how this dilemma between freedom and determinism keeps turning up as wise men try to understand and cope with human action.

Freedom and Determinism: the Dilemma

Just now the universities—all of them—are worrying about what will happen when the new birth-rate floods the admissions offices with would-

be students. How can academe accommodate them all? This matter came up in a certain faculty of a large university some months ago, and the president expressed his concern and gave his advice on how to meet the coming tidal wave. "But why admit so many?" a professor of government asked. "Where," he added, "does the area of decision in this matter lie?" The president was able to discern no such idea. He knew that his university, an endowed institution, could still not remain unconcerned about the applicants it rejects. You might decide for new dormitories but not for a fixed enrollment. The professor, of course, was believing in freedom just then. That is the way governments work: they make decisions. And the two men, the president and the professor, were representing irreconcilable philosophies. Yet no one remarked that incompatibles cannot both be true, for this contradiction is so commonplace that people are fully accustomed to ignore it.

Years ago William McDougall, the psychologist, was my colleague at Harvard. He believed in freedom for the human mind—in at least a little residue of freedom—believed in it and hoped for as much as he could save from the inroads of scientific determinism (*1*). To the determinist-psychologists, such a view was scientifically immoral. John B. Watson, behaviorism's founder, reviewed McDougall's textbook of 1923 under the title "Professor McDougall returns to religion," and you may be sure that Watson was not thinking of himself as a rejoicing father welcoming back a prodigal (*2*). I used to wonder about McDougall and determinism, and then one afternoon in a colloquium —one of those rare occasions when argument brings insight and does not merely serve to harden preconceptions—I found out where lay the difference between us—McDougall, the voluntarist, and me, the determinist. McDougall's freedom was my variance. McDougall hoped that variance would always be found in specifying the laws of behavior, for there freedom might still persist. I hoped then —less wise than I think I am now (it was 31 years ago)—that science would keep pressing variance toward zero as a limit. At any rate this general fact emerges from this example: freedom, when you believe it is operating, always resides in an area of ignorance. If there is a known law, you do not have freedom.

Then there is Francis Hackett's assertion that psychoanalysis did not help the novelist after all (*3*). The novelists thought at first that Freud had presented them with accurate knowledge of human nature—a knowledge that psychology had hitherto failed to provide. Freud did, of course, but he also gave them determinism. Novelists, however, need heroes, and heroes need freedom. What machine was ever a hero to its owner unless the owner—a child undoubtedly—endowed it with freedom and life? You cannot write a novel about robots, unless they are free. The characters must meet difficulty and overcome it, in face of the possibility that they could have failed (*4*). It is the same with an athletic team. A team that won because it was drugged would not be given the trophy. Victory must originate from within the victor, not be rigged in advance.

The Russians—I am relying on Raymond Bauer's excellent historical account of the development of psychology in the Soviet Union—had occasion to discover this dilemma (*5*). In the 1920's they stuck to economic determinism as part of their dialectical materialism—to that and to Pavlov's determinism of conditioning. Then their 5-year plans got into difficulty and, in the early 1930's, the leaders reversed themselves, abandoning Pavlov, conditioning, mental testing, and everything that seemed to make the individual a consequence of causes outside himself. As a substitute they introduced a voluntaristic dynamic psychology, letting praise and blame, responsibility and guilt, operate instead of conditions external to the individual. The leaders themselves, of course, must still have believed in the predeterminism of behavior, for it was they who were to determine the conduct of the people by making them believe they were free and responsible. That the leaders thought they were free to delude the people into believing they were free is pretty obvious.

And then there is my colleague, B. F. Skinner, famous for his patterning of the lives of rats and pigeons and now turning his attention to the teaching of children in the grades (*6*) and to the analysis of psychotic behavior (*7*). He preaches a gospel of how psychological knowledge can be used to improve human living (*8*), and how, as behavioral science advances, human conduct becomes more and more subject to control (*9*). Control by whom, though? Or should one ask, by what? Skinner is saying something more than that behavior is caused, that it is the inevitable consequence of determinable scientific law. He is saying that, because behavior can be controlled, human living can be improved. Not merely that human living will be improved because biological selection promotes human weal willy-nilly, but that it can be and that there is therefore a possibility that it may not be, unless the gospel is accepted. This is sheer voluntarism. It is a mixing of languages, a hoping that hoping itself makes no sense except

as a sign of the existence of a feeling of desire that contributes to the inevitable. Can one choose to do without choice?

It is in this way that the determinist gets trapped in the egocentric predicament (*10*). He has to be outside the system in order to recommend it. He would be more convincing if he would take up his stand firmly on the outside—the man from Mars viewing human society—and describe what is going on, that and nothing more, just as a human being may describe the behavior of ants, without praise or blame for their conduct, or suggestions for improving their social structure, or even the admonition that ants could be happier if they were controlled by positive reinforcement and not by aversive stimulation. A book by a behavioral determinist ought not so much advocate the control of behavior as describe it. Advocacy undermines the argument for determinism because preference belongs to the world of values. You can indeed consider advocacy as a behavioral event with necessary and sufficient antecedents and consequences, but such rigor requires that the author rid himself of preferences and prejudices in his devotion to objective description if his implications are not to subvert his explication.

Truth versus Policy in Scientific Theory

Perhaps I have now already made my point. It is that fact and value, as surely everyone knows, belong in different worlds, each with its own language, and that the wise man must keep both in his repertoire if he is to get along in the culture in which he lives. To me this view means that the wise man is something more than the scientist, who does indeed need, as scientist, to stick to determinism and thus to description. I am saying that science must be something less than the one way to truth. But is not this exactly the principle that prevails today? In 1907, J. J. Thomson remarked that a scientific theory is a policy, not the truth but a view that, if held, gets us ahead—a view to be held as long as it does get us ahead (*11*). Today we hear less about theories and more about models. What is the difference? The theory claims to be true, even though we all know that assurance about the validity of these claims varies greatly from theory to theory and from time to time for the same theory. The theory is an *as,* whereas the model is an *as-if*. The theory is indicative; the model, subjunctive. The model is a pattern to be abandoned easily at the demand of progress. Thus science is less than the whole of wisdom, and the wise teacher of science, being also a human being, will not seek to try to make those other human beings who come under his tutelage less wise or less free than himself.

Now let us examine how this dilemma enters into another field and how it can be met there. Let us consider the great man.

Great Men: Freedom as a Negative Concept

Long ago the problem of freedom and determinism as it pertains to the conduct of great men came up in the contrasting views of Carlyle and Tolstoy. Carlyle, writing about heroes in 1840, was for freedom (*12*). "The history of what man has accomplished in this world," he said, "is at bottom the History of the Great Men who have worked here." Progress is what the great men started. Little is ever said about what started them, for it is conventional to suppose that they are self-starters, creative minds, and it would be derogatory to refer to their causes, if indeed they have any.

Tolstoy—in his *War and Peace* (1869)—was, of course, on the other side (*13*). "A king is history's slave," he said. "History . . . the unconscious, general, hive-life of mankind, uses every moment of the life of kings as a tool for its own purposes. . . . The higher a man stands on the social ladder, the more people he is connected with and the more power he has over others, the more evident is the predestination and the inevitability of his every action." That is, in part, the *Zeitgeist* theory of history, before Matthew Arnold picked that word out of Goethe's writing and made it important. According to this view the great man becomes merely the agent of history. He is not only the cause of his consequences but also the consequence of his causes. You can regard him, if you wish, as a symptom, an event so conspicuous in an otherwise obscure causal train that it comes to be the sign or label by which the whole train is known—like calling all classical physics *Newtonian.*

Herbert Spencer was on the tough side of this argument with Tolstoy. William James was on the soft side with Carlyle. James was promoting scientific psychology in the days when it was very new, but also he was holding tight to the dignity of man. While he wanted us all to meet the new experimental psychologists, "these new prism, pendulum, and chronograph-philosophers," as he called them, he also wished to save the human mind from destruction by "the spying and scraping, the deadly tenacity and almost diabolic cunning" which the scientific attack in the hands of the meticulous German *Gelehrter* threatened to bring about—as James thought.

There is a proximate solution to this great-man

problem, although one that does not go quite far enough. It is that you have freedom only when you are not interested in causal antecedents, in genesis. Everything depends on where you place the boundaries of your universe of discourse. If you are satisfied to consider only great men and their consequences, then of course they appear as free, because you have ignored all the conditions that made them great, the conditions that require the great scientist at the moment of discovery (when there is such a moment) to have the insight that puts him into the histories of science. So the great man is found free, freed by the unconcern of all hero-worshippers.

Now change your point of view, enlarge your universe of discourse, inquire into the antecedents of the great man's great achievement, find out that he was, at least to some degree, anticipated by others, that another man, a small one, independently made the same discovery later, without knowledge of what the great man had done, and then you begin to transform the great man into a symptom and to believe in the *Zeitgeist* as furnishing the climate necessary for great discovery. Thus you move over from Carlyle to Tolstoy, and from William James to Herbert Spencer. Although you have diminished the dignity of great men, you have, on the other hand, enlarged your vision of the causal web of the universe.

It is possible to visualize a model of this causal nexus. Imagine a diagram, plotted between time, which runs from left to right, and simultaneity, which is up and down. Fill it in with separate little circles, each of which is an event—an event like Max Wertheimer's thought on the train in 1910 about perceived movement's being *ipso facto* a phenomenon, the *phi*-phenomenon, the thought that made him get off at Frankfurt-am-Main, buy a stroboscope at the German equivalent of the dime store, and start, after a few billion other events, the school of *Gestalt* psychology (*14*). Now on this diagram draw in all the cause-and-effect relations from every event to its consequents at the right. Simultaneous events are above and below each other and are never connected directly. Multiple causes and multiple effects are, of course, the rule. Every event has many causes and many effects. Now select a crucial event, one of the circles, Wertheimer thinking of *phi* on the train. Put in a boundary line that excludes all the antecedents and includes all the consequents. There you have the model for freedom. Wertheimer is seen as an originator. His idea was *sui generis*. When you think of freedom, you think in these terms. But take away the boundary, and you have before you the entire causal nexus. Wertheimer's insight may now be a necessary link in the system, but there are many others. His insight becomes less special, but your universe of understanding is enormously increased.

The main point here is that freedom is a negative conception. It is the absence of causes. The freedom for which men fight and die is also a negative conception, the absence of constraints. Within science the complaint of the intuitionists about the positivists has been that positivism offers constraints upon scientific freedom; that positivism is a police measure insisting that explanation shall be in terms of *nothing but,* as the protesting intuitionists put it, whereas they, the antipositivists, want not exactly *something more,* for they are not prepared to specify the something more, but freedom to let the inquiring mind advance as it will. This is the faith of the artist who resists control or assessment until his job is done and judgment may be passed. Who shall say that artistic expression should be more rigorously constrained?

So the question is: When is *nothing* better than *something*? And the answer is: You can tell *ex post facto,* and freedom—a negative, a faith in a nothing—has justified itself in more contexts than one.

It is true that, in general, men do not like nothings. Scientists will hold on to a disproved theory for long years until there emerges a better theory to replace the wrong one. Belief abhors a vacuum. So, too, men will hypostatize a negative into a positive, as they have done with the concept of freedom and also with the concept of chance. Both *freedom* and *chance* are terms that are used when efficient causes of present events are not known and often appear to be unknowable.

The scientific view of the history of thought is, of course, the deterministic one. You look for causes and believe in their existence even when you cannot specify them. Tolstoy and Herbert Spencer, not Carlyle and William James. But the scientists' view is often quite different from the scientific view, for a scientist is a human being, required to make value judgments if he is to survive in the milieu in which he has to live. Indeed, there exists what might be called the moral history of science. It deals with the psychological forces that block or misdirect the progress of science and that also drive science forward: the inertias of the scientists, their prejudices, their egoisms, their needs for self-consistency, and also the positives of these negatives—the integrity, the pride, the loyalty of scientists. You might regard these personal characteristics as determining causes which advance or hinder progress, and then you would still be think-

ing scientifically; but actually this is not the way the business of science runs.

Take enthusiasm, for example. Science runs on enthusiasm, gets its research done by dedicated workers; yet enthusiasm is a prejudice, and science is supposed to eschew prejudice. There is a very real conflict here between objectivity and personal drive, a conflict that has the consequence that you ought not to trust the ego-involved theorist, or at least you ought not to be influenced by the intensity of his conviction. His enthusiasm has pushed the pendulum one way, and a better approximation to fact is reserved for posterity, which will have all the evidence before it and none of the distorting enthusiams (*15*). Max Planck said that many a wrong theory could not be abandoned until its author died (*16*).

So what? You can be too scientific to be successful as a scientist. You need your prejudices. Trust posterity to straighten you out, and posterity's posterity to do even a better job.

This is a psychological antinomy. The scientist's mind must make use of incompatible attitudes. He will have to use now one attitude, now the other. Or the necessary combination of incompatibles may be found in a set of men, or perhaps merely in a pair, say, the enthusiastic researcher and the sober handbook-writer. The basic fact remains, however: the prejudiced mind gets more progress into science than does the mind of the critical assessor.

Causes of Belief

In this connection it becomes desirable to inquire into the nature of belief, to ask what use are an organism's beliefs to it, and when, if ever, it is a good thing to believe in error. When is man advantaged by having a great delusion?

There is no need for us to try to distinguish between a belief and a pattern of behavior. The termite believes in a totalitarian society. The life of each termite is devoted to the fulfillment of its role in a complex social organization, which the ethnologist, William Morton Wheeler, once compared favorably to the less efficient, more variable, less assured governance under which man survives (*17*). The newly hatched gosling follows its mother, real or foster, or rather whatever large, dominating animal or other mobile object has come in those early hours of its life to bear the mother-image for it. Lorenz calls this fixation *imprinting* (*18*). It is the gosling's fifth commandment: Honor thy mother and follow her whither she shall go, that thy days may be long—for it is plain that a good belief has survival value.

Those beliefs survive that help the organism to survive: The termite; the gosling; the spider's web; the lioness springing for the throat of her quarry; man's gregariousness. Nor does a belief have to be in the genes. Man's social institutions persist because they are useful to him: forms of government; forms of religion.

Darwin's first principle also applies to these beliefs (*19*). Harmless but no longer useful remnants of originally useful beliefs survive: the cat circling around before it lies down on the parlor rug, as if treading down its bed in the forest; man, baring his second canine in a sneer, though he will not really bite. With man these remnants of useful habits may, however, gain a secondary use as they become means of communication. Your sneer warns the other fellow that you are ready to attack with teeth other than your biological ones.

Generalization may, moreover, preserve a belief that is actually harmful but not distinguished from the useful beliefs with which it is classed. The classical example is the sweet-tasting poison. But what about appetite? The belief in the goodness of eating is basic to the preservation of life, but it can also induce obesity. America is filled with people today who would be better off with a different adjustment of this habit. In a way the fat man's hunger is his great delusion, for he does not need so much food; and man's belief in his own freedom might turn out to be a similar kind of self-deception. It is doubtful that it would be sensible for a termite to believe in personal freedom. For it the good life is fixed by the state.

These human beliefs are, of course, very complex. For instance, is it ever good for man to believe a superstition? Probably yes, but let us consider ritual. Members of a Jewish family keep a kosher kitchen, not because they believe that any biological harm would follow if the two sets of dishes got mixed, but because they like to preserve ancient customs, to have their children perpetually reminded that they belong to a special group which has these customs. Patriotism is similar. The salute to the flag is good because it is symbiotically reinforcing. It makes you one with your compatriots. Both of these kinds of behavior are examples of good false beliefs—that is to say, false in their manifest content, yet good to have because of the psychological effect of having them.

Certainly the belief in human freedom of action is in one sense a superstition, one that is, however, justified biologically by the fact that it is woven into the fine structure of society. Language itself would have to be eviscerated were this conception to be extirpated from it. Beliefs, you see,

can be false as to logical content and good as to use and function. Does not this conclusion settle the problem of freedom? It is a useful superstition.

But no, it does not, for the argument can also be made that causality is another useful superstition. This is what a scientific model is, a useful superstition, for it stands above the observed evidence. So we had better return to our principal inquiry.

Causality as a Model

Against this background I now have three things to say.

1) The behavioral determinist is not wrong. We do indeed want all the controls for human nature that we can get. To prefer ignorance to knowledge is not best—not in the Western culture of this modern age.

2) The model of human nature in social interaction, which is the natural outcome of scientific thinking about behavior, is nevertheless only a model. It is something to have in your repertoire of usable models, something to use on proper occasions. It is pushing science too far to say that this model is true now, but a model does not have to be true to be useful.

3) The analogy that once recommended this model as something that might be true is classical physics, but physics has changed. Causality is not so simple a relation as it seemed to be to LaPlace and to Helmholtz. Physics has become psychological. Operationism says that what you cannot observe does not exist. If you cannot ever observe the position and momentum of an electron simultaneously, then they do not exist simultaneously. Here we are dealing with physical incompatibility, with the physical techniques of observation. In the case we are considering, however, we have only a psychological incompatibility, two attitudes that cannot be assumed simultaneously. The point is that behavioral scientists should not be coerced into too great a simplicity by physical analogy, when physics itself has had to revise its thinking so radically.

Should Behavior Be Controlled?

Sometimes the humanists raise the question, not whether behavior can be controlled but whether it should be (*20*). It is hard for me to take this question seriously. You need all the knowledge of control that you can have. Only then are you prepared to consider how it should be used.

Education and government are instituted for the purpose of human control, and nearly all discussion and debate of any subject are directed at control. I prepare this paper in the hope that by it I may exercise some small degree of thought-control upon all who read it. Skinner claims to have better and surer methods for the design of behavior than have been available heretofore. You should see his pigeons, taught to earn their livings by the rewarding of their successes (not by punishment of their failures). So it is that he envisages a happy society, in which success and reward are the rule, and frustration has been reduced or eliminated by good social design. No one, of course, ever designs frustration into a machine so that it tries to make the same wheel go in opposite directions at the same moment.

One objection made to the behavioral scientists' development of human control is that their power might get into the hands of evil men. This objection seems to me to miss the point. Surely any elite that undertook to use behavioral science to enslave the world would find beneficence more efficient than maleficence. Slavery would be designed as a happy and desirable state, and, if these successful slaves still felt that they needed variety in their companionship, variety can be designed too. All you need is the specifications for n personalities, and the desirable frequency for each of them, to get mass production going.

In any case, you should push knowledge of the means of social control as far as you can. Modern civilization would rather run the risk of being bombed out of existence than return to the complacency of the Middle Ages, when scientific inquiry into natural law was not one of the most important activities of wise men. It is true that the physicists opened a Pandora's box, but what wise man would have stayed them, would have counseled that more safety is to be found in ignorance than in knowledge?

As man alters the world in which he lives, he has to trust that he will be able to adjust it to himself or else adjust himself to it. So far the advance of civilization has consisted of these changes and adjustments, and I see no reason to fear that the behavioral determinists are starting something that will get out of hand. The attempt to control men's actions and thoughts is as old as history. You cannot have social engineering that does not conscript the individual.

Use of Incompatibles

So we come back to the main problem. Do we have to accept incompatibles simultaneously? Perhaps not simultaneously, but certainly alternatively—or so it seems to me. Certainly we all like

to believe that nature is uniform and does not admit contradictions. Nevertheless, it seems clear that there may be limits to the resolving power of the understanding mind. Let me remind you of four such instances.

1) First there are the *antinomies* of Immanuel Kant (*21*). The best known is that you cannot conceive of space as finite nor yet as infinite. What do you do? You admit the contradiction as a limitation of the understanding, and the practical man uses one model or the other as suits his thought. Kant also included freedom and determinism among the antinomies (*22*).

2) Then there is Ralph Barton Perry's *egocentric predicament,* the dilemma that applies especially to our argument (*10*). How can the mind that considers other minds include itself? If I am to see all other men as robots, can this seeing be an event in my own robotic nature or have I got to stay outside the system in order to discuss it? Human nature could be viewed whole by the man from Mars. If n is the population of the world, then at most you could never knowingly have more than $n-1$ robots, for there has to be the 1 left over to do the viewing. In this way one can get around the difficulty of solipsism, not by reducing all reality to events in the Red King's dream, but by ruling the Red King out of consideration. And this was the reason for Max Meyer's writing a psychology under the title *The Psychology of the Other One* (*23*). Everyone counted but Meyer; he wrote the book.

3) Then there are Sir Arthur Eddington's *Postulates of Impotence,* the a priori impossibilities (*24*). The best known is the principle that you cannot detect a uniform translatory motion that is possessed by a system as a whole by means of observations taking place wholly within the system. This is a relativity principle, but it is also a kind of robotic egocentric predicament.

4) And finally there is Bohr's *Principle of Complementarity,* which includes the Heisenberg *Principle of Uncertainty,* that you cannot know both the position and momentum of an electron for the same instant (*25*). This seems to be a physical, not a psychological, incompatibility, but Robert Oppenheimer has told us that Bohr came upon this idea long before he ever formulated it, by thinking about such antinomies as fact and value, the tolerance of pure description as opposed to the intolerance of moral judgment (*26*).

So we do not have to be afraid of embracing incompatibles. It happens every day. Thought is polygamous. As a matter of fact, this kind of polygamy has been enormously eased by the present-day tendency to substitute the model for the theory. The theory had truth-value. It was a claim upon truth, and it had no right to persist—in spite of the fact that habitually it did—in the face of any single contradictory fact. As I have suggested, the theory is an *as,* whereas the model is but an *as-if.* You can have as many models as you want and use them when you will.

Causal determinism is the scientific model. It works enormously well. There are places in science where it breaks down, but they are not many. On the other hand, there are, in the process of living, all the situations in which values are called for and in which the scientific model itself fails. In such cases we get along best with the truncated causality model which we call freedom.

Reiteration

And that is that. Now that I am done I seem, to myself, to have said very little. Yet when I see the humanist battling the scientific behaviorist, seeking to save human freedom and dignity from the ruthless hands of the invading scientist, I feel that something should be said, and this has been it.

Human dignity is all right. It is not silly to want to save it. Robots do not have it. Science does not preserve it. It is an attribute that lies outside of science. It implies that its possessor is free. Freedom is a negative concept, a truncated causality, but it is part of the warp of language. To get rid of this concept would change the whole of our civilization. Yet we need not attempt that, for causality is only the form of a model, and freedom is also a model, and we can use our models at will without letting them dominate us.

One thing more—my parting shot. Do you want to know where to find a free man, a man who acts as if he were free and thinks of himself as free (and how much freer could he be than that)? Go to him who is earnestly trying to persuade you that all men are robots. He will not claim that his ardor was designed into him and has no necessary connection with the validity of what he is saying. If he calls himself a robot, still he will not act like one, for it takes a free man to start a war on freedom. An IBM machine does not have the dignity to make an argument convincing, and an IBMpty organism is a poor evangelist.

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Thomas Henry Huxley

Of the many portraits of Huxley, the most noble one was painted by his son-in-law, the Honorable John Collier, in 1883. Of it Sir Leslie Stephen said: "... in the finest portrait we have the expression remembered by all who saw him; where the old combativeness is represented by the straight-forward glance of the timeworn warrior, but softened by a pathetic glow of the tender and affectionate nature which blends so happily with the sterner expression, and shows the truly lovable converging from, and mutually blending with, the masculine nature." This and the illustrations shown in the article on Huxley, pages 171–182, are from "The Huxley Papers" and were photographed by Charles S. Blinderman of Southern Illinois University, Carbondale. They are published by courtesy of the Imperial College of Science and Technology, University of London.

LETTERS

Present Crisis in Science Education

The June 1956 issue of *The Scientific Monthly* devoted three articles to the present crisis in science education. These articles expressed deep concern for the increasing shortage of scientific and technical personnel, and for the recent trend away from the basic sciences on the part of high-school, college, and graduate students. It is ironic that both Dollard's and Flemming's articles pay lip service to a liberal education, not to enrich our society or to make better citizens, but only to create better scientists.

I feel that this concern is too limited in scope and fails to grasp the over-all needs of our society. Mankind is still reeling from the effects of two world wars in which the whole effort of science and technology was used for the destruction of human life and welfare. These wars and the present international tension prove that there is something basically wrong with Western civilization. Until we can live with and understand each other, this emphasis on science and technology is unjustified. We should be concerned with building a framework of ideals and historical perspective that will enable us to use scientific knowledge for creative purposes. It is essential that our education be able to build a younger generation with a moral and social consciousness.

The tremendous strides of science have made it possible for man to conquer disease and to live in greater comfort than ever before. These new conquests have stimulated anew the hope of a life free from fear and want, luring man farther and farther into science and specialization. In fact, science and technology are progressing so fast that it is a constant struggle to keep abreast of new knowledge. Each scientific discovery opens up new horizons for further investigation. Thus, a vicious circle is set up where science demands more science, and man's intellectual curiosity rushes madly on, unaware that this addiction has drawn him away from the great social problems of the modern world. The basic problem of our time is the search for meaning and value in a world profoundly shaken by the concepts of Darwin, Marx, and Freud, and not the search for new scientific knowledge.

What can be done to remedy the situation? Obviously, there is no simple answer. However, a coordinated, intellectually stimulating effort to teach the humanities at the secondary-school level would be an important step in the right direction. This does not mean permitting a decline in high-school standards by substituting vague courses in social adjustment for the mental disciplines of mathematics, language, and science. It is a challenge for educators to present a concise, dynamic review of the great ethical and political experience of the past to give students a frame of reference for solving problems in the future. Furthermore, this program would try to consolidate and fuse related courses in an effort to prevent specialization and fragmentation of knowledge. It would encourage clear thinking in the field of human relations and help reduce local prejudice. Above all, it should stimulate spiritual resourcefulness and self-confidence in high-school students who are unable to go on to college.

The need for a program such as this is vividly illustrated by what happened to American soldiers who were captured and held prisoners by the communists in Korea. These men were subjected to a systematic breakdown of morale, now referred to as "brain washing." The communists did not try to convert our soldiers openly to Communism; instead they gradually destroyed the soldiers' faith in the American way of life, creating a vacuum in which the will to resist was lost and in which a feeling of mutual distrust developed. Mail containing good news was withheld, but bad news was delivered promptly. The prisoners were encouraged to confess petty crimes to the communists, who rewarded them with extra rations of food. Gradually they became unable to distinguish right from wrong, and they gave information to the communists that was harmful to their comrades. One out of every three Americans who were held prisoner in Korea died. They were not shot, nor for the most part did they die of maltreatment or lack of food. They lost faith in each other and in themselves, abandoned Army discipline, and died because the communists had destroyed their will to live and their desire to help one another.

Why was this possible? Many of the men were just out of high school and were insecure and confused. The communists forced these men to defend their ideals, their country, and the American way of life in open debate or else starve. These men were unable to answer communist arguments and accusations. They knew very little about their government or why they were fighting, and their faith in God and in their country was immature. As a result of the Korean War, it was necessary for

President Eisenhower to proclaim a Code of Conduct for Members of the Armed Forces.

The Eisenhower Code of Conduct is a dramatic symbol of the need for a stimulating program in the humanities at the secondary-school level. Our best minds are needed in the field of political organization, government, art, and economics as well as in industry and research. It is time to carry out a critical analysis of American education to determine whether our persistent emphasis on science and technology is justified in view of the many problems of the modern world.

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What's Wrong with Phonics

It is commonly thought that a very high percentage of our words are spelled as they are pronounced. The various estimates, ranging from 87 to 96 percent, are based on opinions, not facts. Rudolf Flesch, in his recent book *Why Johnny Can't Read,* makes the statement that 13 percent of our words are slightly irregular in their spelling but that 87 percent follow fixed rules. Dorothy Thompson, in the *Ladies' Home Journal* (July 1956), states that 87 percent are spelled as they sound.

However, David Diringer, our greatest expert on the subject, tells us in his book, *The Alphabet,* that alphabetic writing has been an unsuccessful attempt to represent, by symbols, the sounds of the human voice; that a perfect alphabet would have one symbol only for each sound, and one sound only for each symbol. Bernard Shaw, in his will, donated money for phonetic reform.

Webster spells each word as we write it, and then, in parentheses, he spells it as we speak it. In the following lines the words are spelled as he spells them in parentheses:

Dorithi Tomsen sez that ati-seven per sent ov our Ingglish wurdz ar speld az tha sound. She semz not too be akwanted with the faktz.

Noa Webster iz the othoriti for the speling ov our wurdz. He spelz ech wurd as we rit it and then, in parenthesez, he spelz it az we spek it. The speling in this part of the artikl iz from the parenthesez.

If yoo have trubl in pronounsing thez wurdz, yoo ar in the sam pozishun az the children, sins the diakritikal marks ar not indikated in the books tha red. Ol ov our wurdz kontan wun vouel or mor in ech silabl.

The letter *a* haz at soundz, so the child haz at gesez, seven ov hwich ar rong, but wun ges mit be rit. The child has a veri slit chans ov geting ol ov the vouelz rit. Sum wun hoo haz konsulted Noa kan tel him hwich sound too uz, so he won't ned too mak the rong ges and be laft at. Ol the uther vouelz rekwir geswurk, too.

Children are ekspekted too ges hou the wurdz sound, but gron pepl uz a dikshunari, bekoz hili edukated pepl doo not belev in gesing. Tha hav diskuverd that tha ned too be akurit. Kolej profeserz mak a grat del ov us ov the dikshunari bekoz tha hav not lurnd the roolz. But nou children wil no hwen too omit the ekstra leterz in ech wurd and hwen too ad the leterz hwich hav bin omited. Tha wil ad an *f* in *laughter* but not in *daughter.* Olso tha wil omit the *ch* in *yacht,* the *w* in *wrought,* the *k* in *knot,* and not inklud thez leterz in *got, bought, watt, taught, what,* etc.

Children mit ned a speshal rool for ech leter in wurdz lik *one* and *eye,* sins not wun singl leter in thez wurdz iz sounded; *one* ekwals *wun* and *eye* ekwals *i*—but hou? Doo the roolz sa that *o* soundz lik *w,* that *n* soundz lik *u* and *e* soundz lik *n,* in the wurd *one,* or iz this just wun ov the fu eksepshunal pronunsiashunz hwich Roodolf Flesh menshunz?

Sum pepl belev that we rit az we spek. Thez pursnz belev in teching foniks in reding. Tha even advokat lurning ol the roolz before tha pronouns the ritn wurdz. Roodolf Flesh semz too belev that ol the rerz in our speling wer deliberatli wurkt out sientifikali, and that roolz wer emploid in making thez rerz. He klamz that he haz diskuverd thez roolz, and that children kan nou lurn too red without hering the wurd pronounst. The child kan nou edukat himself. But hou kood he lurn the roolz befor he lurnz to red? Ar the roolz ol ekspland in advans? The child mit rezent this dedli dril: it's wurs than the multiplikashun tablz, hwich modern filosofi kondemz.

Wilyum Gra sez that the child is on hiz on in reding, but sum pepl stil belev that the child shood be tot too red; for Ingglish iz lik French, meni leterz ar just for seneri.

We conclude, now, that there are two ways only of knowing how a word is pronounced; to hear it correctly pronounced or to consult a dictionary. The claims for the phonetic method cannot be justified, since Webster found it necessary to tell us how to pronounce each word individually. If there are rules, why then did he not discover them?

Writing and speaking are two separate subjects, and there is much less correspondence in the two subjects than has been supposed. Let us admit the facts.

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Genetics Counselors

In his otherwise welcome review of my new *Human Heredity Handbook* [*Sci. Monthly* **84**, 46 (Jan. 1957)], Harold H. Smith chides me for "an unfortunate omission"—that of not including Curt Stern's name among the human heredity counselors listed in my appendix. May I "un-chide" myself and chide Smith, in return, for not checking the facts as carefully as I did?

While it is true that Stern is eminently qualified to serve as a human genetics counselor and had been listed as such in several publications, I learned, shortly before my book went to press, that he no longer had the time to make his services generally available to the public. Thus, in a letter to the American Eugenics Society (12 Nov. 1955), he wrote, "Please do *not* list my name among those doing heredity counseling. I am doing my best locally and wherever people approach me, but my obligations otherwise do not permit me to devote the amount of time to further counseling which would result from new requests."

Several other qualified human geneticists asked not to be listed for similar reasons, or specified that they be approached only through physicians. In fact, an important reason for publishing my *Handbook* was that there are so few specialists now available for direct consultation in this field, and that most of the questions related to human heredity problems can be adequately answered without imposing on them. (*Imposing* may be the appropriate word because there is often, or usually, no thought of compensating the genetics counselor with a fee.) My book makes clear which problems should be taken up with medical geneticists.

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Colorado Dam Controversy

Argument was recently submitted in these pages for a scientific fact-finding board for consultation on such issues as the Dinosaur National Monument–Echo Park Dam controversy (*1*). Unfortunately for the impartiality of science, it was concluded that such an agency would have repudiated the "semantics of emotionally inspired propaganda" by supporting construction of the dam. With all due respect to Angus Woodbury, who thus endeavored to "analyze the controversy," a brief comment may be appropriate.

Since the analysis focused on the "illegality" of the conservationist position, recounting Senator Watkins' statements to the Senate, the following points about the power withdrawals in the Dinosaur Monument are pertinent: (i) Such withdrawals are routine, administrative paper work in the Federal Power Commission and have no vested-right legality until Congress acts on them. (ii) The enlargement of the monument subsequent to the power-site withdrawals was expressly to preserve the canyons. (iii) Even though the FPC refused to vacate the withdrawals, one form of land-use in effect superseded a previous and opposite commitment, as the Executive order providing for withdrawal was automatically rescinded in Congress' reservation of monument lands from "all forms of appropriation." (iv) The Secretary of the Interior is forbidden, by a 1935 amendment to the Federal Power Act, to license such a project in a national monument.

While most of us would probably support the idea of reference to a detached board of review in such situations, it does not follow that a political decision is inevitably erroneous, or that motivations stemming from emotional convictions are necessarily illicit. Such a board would need, as members, not only engineers and natural scientists but also social scientists, artists, and lawyers. Of course, it would be useless for Congress first to pass such a bill and then refer "minor items of dispute" to an independent body. It is easy to make the charge of emotionalism from selected documents on either side. If a conservationist saw the project as "wily and wasteful," compare, on the other hand, the headlines and editorials of the *Salt Lake City Tribune*, or the pap issued by the advertising agencies employed by the the Upper Colorado River Commission.

From the beginning, opponents of the dam argued that it would establish a precedent, and this argument was never met. A truly historical approach to the habits of Congress would probably reveal its accuracy. The whole national park system was, in fact, endangered—a consideration more crucial than that of whether or not a legal loophole had a shade of validity. The suggestion that the conservation movement was irreparably damaged is curious. The impact on Congress of the united conservation forces was reflected in an estimated 170 to 180 votes in the House (*2*). Surely there has never before been such intracommunication and cooperation, so much financial support, and so wide a public response to a conservation appeal. Not only were the conservation groups mobilized but they won a striking victory against a technologic, public-relations colossus that some may consider representative of the philosophies of pork-barrel exploitation and unlimited

material expansion which threaten important values in American life (*3*).

Not only was the question of conflicting esthetic criteria involved but the economics of reclamation as a whole was in doubt. In opposing only the Dinosaur Dam in the Upper Colorado Project, many conservation groups expediently bartered their convictions for the preservation of Dinosaur Monument.

The article in question takes the desirability of reclamation as a premise: "The main point at issue [is this]: Shall the arid lands of the interior be made habitable . . . or shall they be doomed to remain arid with sparse populations?" Authoritative replies have been made to this question by U. S. Grant III (*4*), Clair Engle (*5*), Leslie A. Miller (*6*), Senator Paul H. Douglas (*7*), and Paul B. Sears (*8*). The latter, whose advocacy of an unbiased board of review has been interpreted as pro-dam sentiment, has frequently expressed the conviction that about one-fifth of our terrestrial habitat should be retained in its natural vegetative cover type to compensate ecologically for intensive use (*9*).

It is unlikely that many natural scientists would seriously question the value for research purposes of natural areas (*10*). Development is inconsistent with the purpose of such reserves. Our national parks and monuments contain a valuable portion of our remaining natural areas (*11*). There are many wild places in America now, but only those explicitly preserved will remain so in the future.

PAUL H. SHEPARD, JR.
Knox College, Galesburg, Illinois

References and Notes

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3. See S. H. Ordway, *Resources and the American Dream* (Ronald, New York, 1953).
4. U. S. Grant III, letter to Senator Watkins, *Dinosaur Journal*, (Council of Conservationists, New York, 1955).
5. C. Engle, *Construction Costs and Repayment on Federal Reclamation Projects* (Committee on Interior and Insular Affairs, House of Representatives, 1952).
6. L. A. Miller, *Reader's Digest*, (May 1955).
7. P. H. Douglas, "Why the Upper Colorado River Project is against the public interest," *Congressional Record*, 18–19 Apr. (U.S. Government Printing Office, Washington, D.C., 1955).
8. P. B. Sears, *Ann. Am. Acad. Polit. and Social Sci.* (May 1952).
9. ———, "Man and nature in modern Ohio," address in lecture series of Ohio State Museum, 14 Nov. 1956.
10. A. Leopold, *Outdoor America* (Dec. 1941). P. B. Sears, *Bulletin of the Univ. of the State of New York* (Mar. 1953).
11. S. C. Kendeigh, *Ecology* **23**, 2, 236 (1942). Nature Conservancy Inventory Committee, *The Living Wilderness* **15**, 35 (1950–51).

In reply to Paul Shepard's criticism, may I restate the essence of my position, which I think he has misinterpreted. Congress made the decision many years ago, to develop the Colorado Basin water supplies and initiated development of the lower part about 1928. In implementing development of the balance of the river system (the Upper Basin), a controversy arose concerning the dams to be built—not the larger question of the Reclamation Service Program. I called on the Sears proposal for use as a fact-finding body to furnish scientific information to Congress—not to persuade Congress to build dams. That decision had long since been made.

I interpret conservation to mean the wise use of natural resources in order to serve human uses in balanced proportions and pass these resources on to future generations in wisely used condition. Human use requires space for homes, farms, industries, and other needs; food and clothing of many kinds; water for culinary, agricultural, and industrial uses; power to do physical work and lighten human labor; natural areas and sanctuaries of many kinds; recreation facilities; and many other things.

For these purposes, we back the conservation of forests, ranges, parks, wildlife refuges, water supplies, natural areas, and other resources. Some people concentrate their support behind specific items, such as natural areas or national parks, and forget to balance their values against values of other things. I have tried to look at the whole picture, and I refuse to be pushed into the role assigned me by Shepard. It is easy for a person who has no real acquaintance with the problems involved in the tremendous scenic areas of the West to say that Echo Park, one of our less valuable canyons, should not be utilized for a larger good. We in the West wish to weigh these things dispassionately and put areas to their best use. In this, the Sears approach would help.

ANGUS M. WOODBURY
University of Utah, Salt Lake City

Correction

In the article "Studies on deep mass culture of algae in Israel" [*Sci. Monthly* 83, 198 (October 1956)], the incorrect expressions "kilowatts per day" and "watts per day" were used several times. The correct units would be "kilowatt hours per day" and "watt hours per day."

A. M. MAYER, A. EISENBERG, M. EVENARI
Hebrew University, Jerusalem, Israel

Erratum

In "Formation of the elements," by William A. Fowler [*Sci. Monthly* 84, 84 (Feb. 1957)] an unfortunate typographic error occurs in the legend to Fig. 6 on page 95. The last two lines should read ". . . leaving beryllium-8, Be^8, which breaks up into two alpha-particles."

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AAAS MEMBERSHIP

1) *Changes during 1956*

New members		6,626
Losses		
Deaths	241	
Resignations	1,453	
Automatic resignations	2,403	
Total loss		4,097
Net increase during 1956		2,529

2) *Totals as of 31 Dec. 1956*

Paid for 1956	33,127
Paid through March 1957	1,358
Paid through June 1957	12,926
Paid through Sept. 1957	929
Life members, etc.	863
In good standing	49,203
In arrears	2,491
	51,694
New for 1957	1,024
Total membership	52,718

NEW YORK MEETING IN RETROSPECT

No two scientific meetings are ever alike, not even two consecutive annual conventions of the same society or two meetings of the same organization in the same locale. This generalization is particularly obvious with the large-scale, diversified annual meetings of the American Association for the Advancement of Science which, uniquely, bring together scientists of all the principal disciplines, research directors, academic administrators, teachers, students, writers, editors, more than one philosopher, and an increasing number of science-minded members of all the major professions. Inevitably, old friends are seen and new friends are made; ideas are engendered and expressed, discussions planned and unplanned occur; concepts are sharpened; and lasting impressions may be received. The great majority of those who attend return to their laboratories, classrooms, and offices stimulated to further work and thought. Thus, the real measure of the success of any scientific meeting would be the sum total of the effects of this commingling of trained minds, the journal articles and symposium volumes which ensue, the new directions of research taken, and the increase in vigor with which long-standing problems are reattacked. If so, the full impact of any AAAS meeting comes in subsequent years—and scarcely can be completely evaluated either immediately afterward or later.

Some indication of the significance of a particular meeting, however, is available in the number and identity of those who attend and in the quality of the programs which attract them. Not infrequently, actions are taken in the business sessions which are important milestones or turning points. In significance, thus suggested, the Association's seventh New York meeting, 26–30 Dec. 1956, may prove to have been one of its greatest. The two sessions of the AAAS Council were reported in the March issue, and the caliber of the many programs was apparent in the General Program-Directory.

There were 5327 registrants. Characteristic of all AAAS meetings, the Visible Directory of Registrants included representatives from all sections of the continent and an impressive group of top-level investigators, Nobel prize winners, and high-ranking research administrators.

In summary, this annual meeting of the Association for 1956 was particularly well attended, well balanced, and memorable, and there were numerous spontaneous complimentary remarks on the excellent general "tone." When the various aspects are considered, it is clear that the meeting was decidedly successful in most essential respects.

Arrangements for the meeting. Early each spring the secretary of each section and participating society is asked to estimate the probable number of sessions and his best guess of the probable attendance at each. It is easy to over- or underestimate when, at this stage, the programs are still far from complete and calls for papers may not have gone out. Soon afterward, on the basis of session room requirements and preferences, the headquarters hotels for related sections and societies are selected.

In New York, the large Entomological Society of America utilized the relatively limited number of public rooms of the Hotel New Yorker and, in the interest of a compact and convenient meeting, as many sessions as possible were scheduled in the remaining Penn Zone hotels—the Statler, Governor Clinton, Sheraton-McAlpin, and Martinique. Related groups of societies and sections, especially when there were interdisciplinary programs planned, were assigned to the hotel that could best meet their needs. The intensive use of the Statler, AAAS headquarters, for instance, necessitated the simultaneous use of the three divisions of the Penn Top—not an ideal arrangement but satisfactory when the folding partitions are fully closed and the microphone in the largest room is kept at a moderate pitch (speakers do not always adjust the height of the instrument or face it).

Most of the local scientific organizations and a number of the educational institutions made their facilities available for sessions. The AAAS gratefully acknowledges these. The American Astronomical Society held its sessions at the Hayden Planetarium, Roosevelt Hall of the American Museum of Natural History, and the Henry Hudson Hotel. The American Museum of Natural History was also the site of an excellent informative symposium on museum techniques and demonstrations of exhibit preparations, sponsored by the museum and arranged by Gordon Reekie of the staff; of the sessions of the Society of Vertebrate Zoology; and of the tenth annual Junior Scientists Assembly, sponsored jointly by the Academy Conference and the AAAS as a whole. Two societies had special tours of the museum, and doubtless numerous individuals among the attendance visited it.

The New York Academy of Science's two-session symposium, "Modern ideas on spontaneous generation," joint with AAAS Section F, was held at the Hotel Barbizon-Plaza; a joint symposium with the Ecological Society of America, "Values in human ecology," was held in the academy's auditorium and was followed by a luncheon. The Cornell University Medical College was the locale of the program of Alpha Epsilon Delta; there were dinners at the faculty clubs of Columbia and New York Universities; Alpha Chi Sigma greeted visiting chemists at the Chemists' Club; and the silver anniversary celebration of the Gordon Research Conferences was held at the Hotel Commodore. The New York Botanical Garden arranged an open house 26 Dec., and the New York Zoological Society–Bronx Zoo had daily guided tours 27–31 Dec. for zoologists and other interested scientists. The Museum of Modern Art lowered its entrance price to accommodate all AAAS registrants.

The local Committee on Physical Arrangements always has one of the most taxing assignments. Commonly, more than 200 sessions will require projection, often with two or more types per session. Lanterns must be assembled, determined as suitable for the size of the room and the session in each case, tagged with respect to both source and session room, transported to the hotels, checked in and out of each storage room, repaired, supplied with spare lamps, and the like. Personnel must be engaged both to deliver and to operate the equipment.

In New York, with very few exceptions, all projection equipment was lent by the Audio Visual Department of New York City's five-borough Board of Education. The number of lanterns moved into each of the five hotels on 20 Dec., the last "working day" before the first day of the meeting, was based on the projection requirement forms that had been returned to the Washington office of the Association by most, but not all, of the program chairmen. Some "extras" were provided in anticipation of last-minute requests for projection—but such requests, more numerous than usual, did tax the supply in several of the audio-visual "centers" established in each hotel. In general, the lanterns were distributed and collected by technicians employed in the school system who volunteered their services, but there were instances where impatient presiding officers helped themselves, got lanterns intended for other rooms, and thus caused temporary shortages. An extreme instance was the report that one chairman took *three* lanterns which

he planned to operate *seriatim,* and thus save several seconds per slide.

Despite the difficulties mentioned, the Committee on Physical Arrangements did a generally excellent job and all concerned are deeply indebted to the many who served without pay and, in particular, to the co-chairmen, Samuel Schenberg, supervisor of science, Board of Education, who was present throughout the five days to direct operations, and Edward G. Bernard, director of visual instruction in the city's school system. Thanks are also due to the many program chairmen who arranged for volunteer operators from their attendance and to the operators themselves. The services rendered were substantial. For those instances where the audiences were inconvenienced, sincere regrets and apologies are expressed.

Besides some temporary shortages of lanterns and screens, the causes of which were various, other unforeseen incidents occurred which also inconvenienced the session chairmen, speakers, and the audiences concerned. For the first time in 15 years, on one morning of the meeting period, the New York Statler suffered from "cold mikes." The explanation: All PA systems in that hotel are operated from a central control room and usually only the two assigned engineers are familiar with the maze of switches and pilot lights. On the morning in question, Engineer A telephoned in that he could not report for duty because his child was sick; Engineer B, commuting in to work, would have been there on time if the train he was on had not hit an automobile and been delayed some 45 minutes. Eventually, the top management of the hotel got every microphone in operation by the simple expedient of throwing every switch in sight.

On the last afternoon of the meeting, at one hotel, an important program did not conclude at 5 P.M. as the hotel management had anticipated. The hotel owner's daughter's wedding reception was scheduled for 8 P.M. in that room. In their zeal, the workmen setting up for the reception disconnected the lantern at 5 P.M. and, at 5:30 P.M. insisted that the meeting end then, although another 15 minutes would have accommodated the final speaker. For this unhappy incident, which never should have happened, only regret can be expressed at this time, to all those affected.

In the absence of other reports, it is believed that most of the 357 sessions did find that the arrangements made for them were satisfactory.

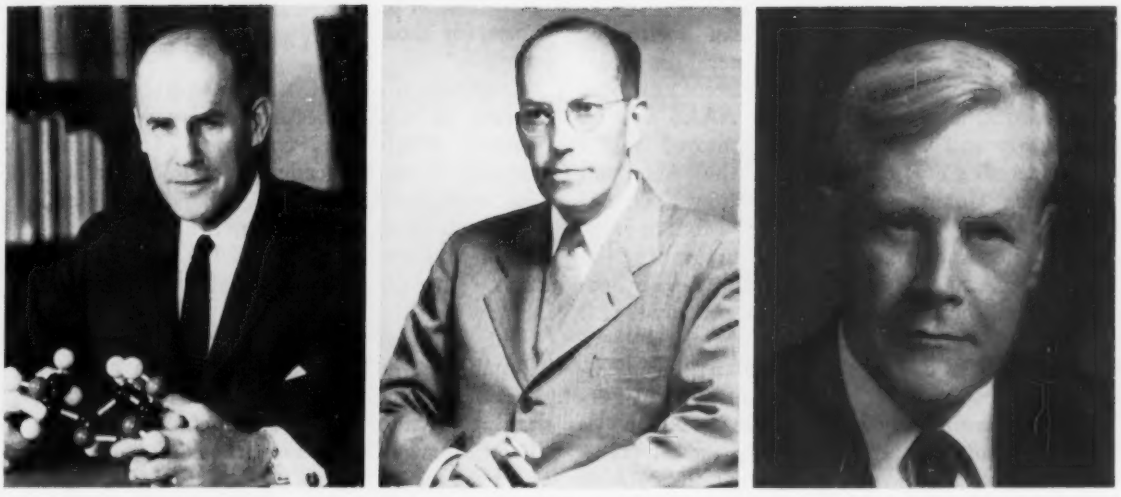
Highlights of the meeting. The seventh New York meeting enjoyed an unusual number of events which will stand out in the memories of those who attended them. Included were the two-session AAAS General Symposium, "Moving frontiers of science," four commemorative programs, and the special evening sessions.

The commemorative programs were (i) a symposium, "Commemorating the 100th anniversary of the discovery of Neanderthal man," a joint program of AAAS Section H (Anthropology) and the American Institute of Human Paleontology, arranged by Loren C. Eiseley and William L. Straus, Jr.; (ii) a symposium, "The general significance of the work of Freud," commemorating the centennial of his birth, a joint program of AAAS Section L (History and Philosophy of Science) and the American Philosophical Association, Eastern Division, cosponsored by the Philosophy of Science Association, arranged by John Wild and Jane M. Oppenheimer; (iii) a Botanists' Dinner and vice-presidential address, sponsored by AAAS Section G (Botanical Sciences), in celebration of the 50th anniversary of the founding of the Botanical Society of America; and (iv) the 25th anniversary dinner of the Gordon Research Conferences, a participating organization of the AAAS, at which Glenn T. Seaborg spoke on "The future through science."

The special evening sessions included, on 27 Dec., a joint annual address of the Society of the Sigma Xi and the Scientific Research Society of America, "Science, technology, and society," delivered by Lawrence R. Hafstad, who received the William Procter prize of RESA; and the 17th annual address of the United Chapters of Phi Beta Kappa with the AAAS, "Toward more vivid utopias," given by Margaret Mead.

The concluding special session, 29 Dec., was a first showing of the National Geographic Society's film, *Southeast Asia's Golden Pageantry,* and lecture by W. Robert Moore, chief of the foreign editorial staff of the society. This annual lecture with the AAAS, appreciated by all, was cooperatively scheduled for 7 P.M. so that the AAAS Smoker could follow in the same and adjacent rooms.

AAAS presidential address and reception. On the customary evening, 28 Dec., the traditional address by the retiring, 108th president of the Association, George W. Beadle, was given before an audience which overflowed the capacious ballroom of the Hotel Statler. AAAS president, Paul B. Sears, presided and introduced each speaker with appropriate remarks. Eugene Holman, president of Standard Oil Company (New Jersey) and general chairman of the seventh New York meeting, on behalf of the local committees, graciously welcomed the Association and the audience to New York and, as a petroleum geologist now an ad-



Left to right: Wallace R. Brode, president-elect, and William W. Rubey and Alan T. Waterman, new members of the board of directors of the AAAS. Dr. Brode is associate director of the National Bureau of Standards; Dr. Rubey is research geologist at the U.S. Geological Survey; and Dr. Waterman is director of the National Science Foundation.

ministrator, he was particularly competent to point out briefly the interdependence of science and industry.

Richard L. Rosenthal, in announcing the winners of the second AAAS-Anne Frankel Rosenthal Memorial Award for Cancer Research and the first AAAS-Ida B. Gould Award for Research on Cardiovascular Problems, explained the purposes of these awards which are financed by the Richard and Hinda Rosenthal Foundation. President Sears, after a brief tribute to a distinguished scientific career in biology and genetics, then introduced the principal speaker of the evening.

George W. Beadle's thought-provoking address, "The uniqueness of man" [*Science* **125,** 9 (4 Jan. 1957)] sketched the origin of the cosmos, outlined some of the probabilities of chemical and organic evolution which had culminated in the one species, man, uniquely able, to a considerable extent, to control or modify his environment—and now with the capacity to destroy all life. Discussing the increasing dangers of rising populations, consumption of raw materials and food, the need for new sources of energy, and the necessity to abolish war, he concluded by pointing out that not only knowledge but wisdom, courage, and faith are essential if man is to realize the still greater achievements that are possible.

The AAAS reception which followed was well attended and, for those in the receiving line, it was a pleasure to greet so many members and friends of the Association.

AAAS general symposium.

Fundamental units and concepts of science was the topic of a general symposium held on the afternoons of 27 and 28 Dec. The symposium, which was arranged by the Committee on AAAS Meetings, consisted of a lively interchange of sometimes sharply contrasting views on the nature and role of theories in different areas of science.

On the first afternoon, papers were presented by Robert MacLeod (social sciences), Ralph W. Gerard (biological sciences), and Jerrold R. Zacharias (physical sciences). The papers were discussed, in order, by Paul F. Lazarsfeld, Paul Weiss, and Jerome B. Weisner. The second afternoon opened with a paper by Michael Polanyi and concluded with a panel discussion among all of the participants. Howard Mumford Jones served as moderator for both sessions.

Other symposia. The trend toward a large number of symposia at AAAS meetings continued, not only among the sections of the Association but also among the participating societies. There were 133 symposia, panels, groups of invited papers, or other sessions centered about a particular theme. At the seventh New York meeting there were about twice as many sessions devoted to programs of this type as to sessions for contributed papers, although 12 societies, one of them quite large, were holding their national meetings with the Association. The participating societies, especially the 41 which arranged special meetings, in the aggregate had almost as many sessions of this type as the AAAS and its 18 sections. The 640 symposium participants outnumbered the 542 other speakers.

Among the 133 symposia, the following were noteworthy for their interdisciplinary scope: "Chemical and biological aspects of cellular competition," sponsored by AAAS Section C (Chem-

istry), cosponsored by the American Society of Naturalists and the Society of General Physiologists, arranged by Werner Braun; "Recent advances in geochronometry," sponsored by AAAS Section E (Geology and Geography), cosponsored by the Geological Society of America, the American Geophysical Union, and, in part, Sections F, G, and H, arranged by J. Laurence Kulp; "Modern ideas on spontaneous generation," a joint program of the New York Academy of Sciences and AAAS Section F (Zoological Sciences), cosponsored by AAAS Section G (Botanical Sciences), arranged by a committee, Ross F. Nigrelli, chairman; "Biochemistry of the cell nucleus," sponsored by AAAS Section F, cosponsored by Section G and the Genetics Society of America, arranged by Arthur W. Pollister; "Problems of aging," a joint program of AAAS Sections F, G, and I (Psychology) and the American Society of Zoologists, sponsored by the U.S. Atomic Energy Commission through the Brookhaven National Laboratory, arranged by H. J. Curtis, Paul J. Kramer, and Conrad G. Mueller; "Some unsolved problems in biology," sponsored by Section G and cosponsored by Section F and the Botanical Society of America; "Biotic communities in the past and today," a program of the Society for the Study of Evolution, cosponsored by the Society of Vertebrate Paleontologists and the American Society of Naturalists, arranged by Harlan Lewis; "The impact of natural science on social science," a joint session of Section K (Social and Economic Sciences), the National Academy of Economics and Political Science, and the American Political Science Association, arranged by Donald P. Ray; "Science and ethics," sponsored by AAAS Section L (History and Philosophy of Science) and the Philosophy of Science Association, arranged by Joseph Mayer; "Evolution of nervous control from primitive organisms to man," the four-session symposium of AAAS Section N (Medical Sciences), arranged by Bernard B. Brodie; "Aids for environmental control," sponsored by AAAS Section M (Engineering), cosponsored by AAAS Sections C, H, I, K, L, and N, and the Conference on Scientific Manpower, arranged by Eugene F. Murphy and Irving P. Orens; "Antienzymes," a joint program of AAAS Sections Nd (Dentistry), C, N, and Np (Pharmacy), arranged by George C. Paffenbarger, Ed. F. Degering, Allan D. Bass, and John E. Christian; and "Grasslands in our national life," sponsored by AAAS Section O (Agriculture), cosponsored by AAAS Sections G and K and 17 societies, endorsed by 11 other organizations, arranged by Howard B. Sprague. The Association expresses its deep appreciation to the 640 persons who prepared papers for these and the other, more specialized symposia.

Conferences. All of the three recurrent conferences at AAAS meetings had programs. The Academy Conference, composed of the official delegates of the 41 academies of science affiliated with the Association and others interested in academy affairs, had a day and a half of sessions culminating in a dinner at which Father Patrick H. Yancey gave the Academy Conference presidential address.

The program of the Conference on Scientific Manpower, which was arranged by a committee headed by Thomas J. Mills and cosponsored by the Engineering Manpower Commission, the Scientific Manpower Commission, the National Research Council, the National Science Foundation, and AAAS Section M (Engineering), was concerned with the program of the National Committee for the Development of Scientists and Engineers and its implications for the physical sciences, for engineering, and for the life sciences.

The Conference on Scientific Editorial Problems, the program chairman of which was J. G. Adashko, had six well-attended sessions. One of these was cosponsored by the Technical Publishing Society and another by the Association of Technical Writers and Editors; members of these organizations contributed to the attendance and participated in the discussions.

AAAS business sessions. As is required by the constitution, the Association's board of directors held its fourth regular meeting of the year at the annual meeting; as usual, its sessions preceded the two sessions of the Council, 27 and 30 Dec., which were reported elsewhere. It is gratifying that these sessions, especially the one on 27 Dec., with 157 members present, were well above the attendance of previous years. The AAAS section officers' luncheon and business meeting held on 29 Dec. was well attended. There was helpful discussion on the tentative plans for the Indianapolis meeting.

Attendance. In sheer size, with 5327 registrants, the seventh New York meeting was the second largest in the 108-year history of the Association, exceeded only by the previous New York meeting of 1949—when a record-breaking number of large societies held their national meetings with the AAAS. (In number of registrations, the seven largest AAAS meetings have been: New York, 1949—7014; New York, 1956—5327; Chicago, 1947—4940; Washington, 1924—4206; New York, 1928—3925; Berkeley, 1954—3856; and Philadelphia, 1951—3702. To date, only 11 of the 123 AAAS meetings have exceeded 3000 registrants.) It is always true that the *total* attendance of professional

scientists, faculty members, other teachers, and graduate students at any national meeting of the Association is always greater than the number of registrations, since all programs are open to everyone. Some register only with their societies, apparently regarding a "double registration" as superfluous or onerous. Finally, there are commonly several thousands of the science-minded general public who attend the evening lectures or some one event who do not register at all. At New York it is probable that an additional 10,000 attended one or more of the 357 sessions or visited the Annual Exposition of Science and Industry, the 70 exhibitors of which filled 92 booths.

Hotel room reservations and especially advance registrations had suggested a larger-than-usual meeting, but it was not until after the heavy registrations of the first two days that it became probable that this 123rd AAAS meeting would surpass the 1947 meeting in Chicago when, as in 1949, so many large societies met with the AAAS.

As Table 1 shows, slightly less than one third of the total registration came from New York City and suburbs—the nation's most populous educational and scientific center; approximately one eighth came from nearby New Jersey and Connecticut; and the remainder, about 56 percent, came from a substantial distance—upstate New York, the other 47 states (with the sole exception of Nevada), the District of Columbia, and Canada. There were 48 scientists who represented 27 other countries and territories; most of these were visiting scholars at American institutions, but Michael Polanyi, for example, came from England especially to attend the meeting.

The large attendance from so many geographic sources demonstrated that, when programs of the symposium type are well chosen with respect to subject and are of high quality, a gratifying number of scientists and members of societies not meeting with the AAAS will travel substantial distances to attend them. On the other hand, although the Association, its 18 sections, and its conferences can ensure a good-sized convention, at least in a large metropolitan center, it is clear that the participating societies contribute a substantial and desirable "core attendance" and a welcome additional diversity of interests. At the seventh New York meeting, 12 societies participated with annual national meetings—the American Astronomical Society, American Documentation Institute, American Nature Study Society, Entomological Society of America, History of Science Society, National Association of Biology Teachers, Scientific Research Society of America, Sigma Delta Epsilon, Society of the Sigma Xi, Society for the Study of Evolution, Society of Systematic Zoology, and the Society of Vertebrate Paleontology. Forty-one other societies arranged special or regional meetings—notably the Ecological Society of America and the American Psychiatric Association, with seven sessions and a four-session symposium, respectively. Finally, an additional 33 societies were the formal cosponsors of the programs of appropriate sections or other societies.

Table 2 shows the 5327 registrants analyzed by subject fields, except in 137 instances where this line on the registration slip was left blank and no other clues were available. In this analysis, every effort was made to record each individual's primary interest; if secondary interests had been recorded, some of the geologists were also geographers,

Table 1. Distribution of registrants by states and countries.

Alabama	8	Texas	37
Arizona	5	Utah	9
Arkansas	4	Vermont	12
California	97	Virginia	98
Colorado	18	Washington	10
Connecticut	215	West Virginia	8
Delaware	52	Wisconsin	50
District of Columbia	199	Wyoming	3
Florida	42	Total, continental U.S.	5220
Georgia	28		
Idaho	2		
Illinois	137	Alaska	2
Indiana	60	Australia	2
Iowa	30	Austria	1
Kansas	20	Brazil	5
Kentucky	19	Canada	59
Louisiana	37	Colombia	1
Maine	14	Denmark	1
Maryland	243	England	1
Massachusetts	260	France	1
Michigan	109	Germany	1
Minnesota	28	Hawaii	3
Mississippi	4	Honduras	1
Missouri	30	India	6
Montana	8	Italy	1
Nebraska	13	Jamaica	1
New Hampshire	24	Japan	2
New Jersey	638	Liberia	2
New Mexico	6	Mexico	3
New York		Monaco	1
Upstate	321	Nepal	1
Suburban	341	New Zealand	1
New York City	1365	Panama	1
North Carolina	40	Philippines	1
North Dakota	6	Puerto Rico	3
Ohio	140	Saudi Arabia	1
Oklahoma	5	Spain	1
Oregon	6	Sweden	2
Pennsylvania	330	Taiwan	2
Rhode Island	27	Total, territorial and foreign	107
South Carolina	17		
South Dakota	2	Total registrations	5327
Tennessee	43		

Table 2. Registrants by subject fields.

Mathematics and statistics	86
Computers	36
Physical sciences	
Physics	187
Meteorology	6
Astronomy	202
Chemistry	276
Geology and paleontology	117
Geography	23
Engineering and industrial science	154
Biological sciences	
Mycology	18
All other botany	157
Ecology	86
Evolution	16
Genetics and cytology	95
Microbiology	54
Parasitology	13
Entomology	599
All other zoology	285
Biology (in general, and other)	301
Agricultural sciences	78
Medical sciences	
Bacteriology and virology	42
Biochemistry (including nutrition)	209
Physiology	130
Psychiatry	62
Public health	9
Dental research	72
Pharmacology and pharmacy	224
Medicine (in general, and other)	288
Psychology	193
Economic and social sciences	
Economics	16
Sociology and criminology	47
Anthropology	147
History and philosophy of science	81
Science teaching and education	531
Scientific editorial problems, technical writing, and documentation	172
Interest in three or more sciences	178
No field indicated	137
Total	5327

paleontologists were interested in evolution, high-school science teachers could have been classified as biologists or chemists, and so on. If the data on the different disciplines were grouped under still broader headings, the composition of the registered attendance was:

Physical sciences and applications	1064	20%
Biological sciences and agriculture	1702	32%
Medical sciences	1036	20%
Psychology, anthropology, and social sciences	507	9%
Science teaching and education	531	10%
General interest and other	487	9%
	5327	

Exhibitors of the books, instruments, and laboratory supplies which scientists and teachers use have an understandable interest in the composition of the attendance at AAAS meetings. From the foregoing data—and also bearing in mind that so many of the registrants were department heads, directors of research, and others in a position to decide on textbooks and other materials—it is apparent that a AAAS meeting, diversified as it is, is well worth the participation of those who produce the things scientists need and, collectively, the meeting provides an exceptional opportunity for large industries to show some of their technological accomplishments.

Annual Exposition of Science and Industry. The 1956 Annual Exposition of Science and Industry filled the Georgian Room, Foyer, and Ivy Suite on the mezzanine of the Hotel Statler and overflowed around three sides of the mezzanine well or upper lobby; in the center of the rotunda, on loan from *Look* magazine and under the auspices of the Department of Geology, Columbia University, was a 6-foot 6-inch globe of the world with carefully executed relief features of all continents. Necessarily, aisles were narrower than ideal, but the close proximity of the exhibit area to the AAAS main registration, Visible Directory of Registrants, Press Room, and the hotel's principal session rooms made the exposition of maximum convenience for visitors. Altogether, there were 92 booths.

The names of most of the 70 exhibitors and descriptions of their exhibits appeared both in the General Program-Directory and in the preconvention issue of *Science*. Those that did not are listed here: AAAS Advertising Department; Columbia University, Department of Geology; Foundation for Integrated Education; Geophysical Maps, Inc.; IMPCO, Inc.; Otto Klein, Publishers; P. M. Lennard Company; E. Leitz, Inc.; New York State Society for Medical Research; and Street and Smith Publications, Inc.

The exhibitors of the seventh New York meeting have already expressed their satisfaction at the contacts made; indeed, exhibitors not participating at New York have already indicated their interest in the 1957 Indianapolis meeting of the Association.

AAAS Science Theatre. The Science Theatre, which shows a selection of the latest foreign and domestic scientific film, was inaugurated at the Chicago meeting of 1947. It is now an established feature of the annual meetings of the Association. At New York the theatre was located in the East Room of the Hotel Statler in proximity to both the ballroom and the Annual Exposition of Science and Industry. For the nine programs given during

the week, the 200 chairs were well filled by ever-changing audiences. Many came to see a particular film and stayed for several more. The 31 different films listed in the General Program-Directory were shown twice, and a few three times. *Nuclear Reactors for Research,* produced by North American Aviation, was substituted at the last minute for *The Sodium Reactor Experiment Fabrication,* produced by the same company, because of an unanticipated later release date. We were particularly sorry that a not very well conceived film on petroleum was inadvertently substituted by the Los Angeles office of the Modern Talking Picture Service for *A Report on Smog,* Stanford Research Institute's latest summary of the subject, and we apologize to those who came from a distance especially to see it. The time allotted to the second showing of this film was filled by a film entitled *Blood Vessels and Living Pathology,* produced by the Medical Film Guild from materials supplied by two professors, Lutz and Fulton, department of biology, Boston University. The Association again expresses its appreciation to those who so kindly lent such excellent subjects.

Work of the local committees. A scientific meeting as large and as complex as the annual meeting of the AAAS does not just happen. It cannot take place, nor can it succeed, without the cooperation and assistance of a great many agencies and persons. Of critical importance among these are the local committees and the general chairman who appointed them. The Association and all who attended the seventh New York meeting are much indebted to Eugene Holman, chairman of the board, Standard Oil Company (New Jersey), who made distinguished appointments to the local committees, kept in close touch with all phases of the meeting, and graciously welcomed members and friends of the Association the evening of 28 Dec. On behalf of the Association, a grateful acknowledgment of the extent of our indebtedness to Mr. Holman is made here.

Deep appreciation of the work of the Committee on Physical Arrangements, headed by Samuel Schenberg and Edward G. Bernard, was made earlier, under the section on arrangements. There were three other committees and each of them filled an indispensable key role. The Association expresses its gratitude to the members of all four committees and, in particular, to those whose names follow. The Exhibits Committee, under the chairmanship of Albert Bradley, chairman of the board, General Motors Corporation, assisted materially in enlisting the presence and support of industrial exhibitors that otherwise would not have been present. The Committee on Public Information, headed by Marion Harper, Jr., president of McCann-Erickson, Inc., and its associate, Communications Counselors, Inc., vice president Murray Martin in charge, provided expert advice and assistance in publicizing the meeting locally. Pre-meeting announcements in the press are not readily secured (probably on the principle that a meeting is not news until it happens!) but the local scientific societies, and the local press, radio, and television in New York did provide an exceptional amount of advance information on the meeting.

The Finance Committee, through its able chairman, W. J. Murray, Jr., chairman of the executive committee, McKesson & Robbins, solicited funds to reduce the deficit of the meeting. It is anticipated that when all replies are in, the deficit will have been resolved. Firms and individuals who have made contributions include:

American Telephone and Telegraph Company
American Tobacco Company
Armco Foundation
Bell Telephone Laboratories
James F. Brownlee, partner, J. H. Whitney & Company
Frederic W. Ecker, president, Metropolitan Life Insurance Company
Econometric Specialists, Inc.
Fred Emmerich, president, Allied Chemical & Dye Corporation
Equitable Life Assurance Society
Food Machinery and Chemical Corporation
General Motors Corporation
Harold H. Helm, chairman, Chemical Corn Exchange Bank
International Business Machines Corporation
International Nickel Company, Inc.
International Paper Company
International Telephone and Telegraph Corporation
Eli Lilly and Company
McKesson & Robbins
Merck, Sharpe & Dohme
National Dairy Products Corporation
Owens-Corning Fiberglas Corporation
S. B. Penick & Company
Radio Corporation of America
Smith, Kline & French Laboratories
Standard Oil Company (New Jersey)
George Van Gorder, chairman of the board, McKesson & Robbins
Warner-Lambert Pharmaceutical Company
Sidney J. Weinberg Foundation
Western Electric Company

To these should be added a contribution made for

the fourth time by the United-Carr Fastener Corporation of Cambridge, Mass., to the AAAS for any worthy purpose and applied to the seventh New York meeting.

Other acknowledgments. At the AAAS Smoker, as in past years, the Coca-Cola Company through the Coca-Cola Bottling Company, of New York, the National Biscuit Company, and Philip Morris, Inc., generously donated their products. The Association gratefully acknowledges these generous and recurrent donations.

In concluding this report of the seventh New York meeting, I wish to express my personal appreciation to Royal W. Ryan, Walter R. Potts, and others of the staff of the New York Convention Bureau, who have supplied expert professional assistance and friendly help throughout; to the managements, sales managers, and other key personnel of the Statler, Sheraton-McAlpin, and other hotels for their many courtesies and assistance; and to the secretaries and program chairmen of each section and participating organization for their able cooperation, especially with reference to copy and galley proof for the 400-page General Program-Directory.

Awards and prize winners. The following annual awards were made during the meeting: 29th AAAS Newcomb Cleveland prize to Neal E. Miller, James Rowland Angell professor of psychology, Yale University, and James Old, associate research psychologist, department of anatomy, University of California at Los Angeles [*Science* **125,** 60 (1957)]; 12th Theobald Smith Award in the Medical Sciences, to Oscar Touster, associate professor of biochemistry, Vanderbilt University [*Science* **124,** 1287 (1956)]; 2nd AAAS-Anne Frankel Memorial Award for Cancer Research, to Jacob Furth, associate director of research, Children's Cancer Research Foundation, Harvard Medical School [*Science* **125,** 60 (1957)]; 1st AAAS-Ida B. Gould Memorial Award for Research on Cardiovascular Problems, to C. W. Lillehei and Richard Allison De Wall, University of Minnesota School of Medicine [*Science* **125,** 60 (1957)]; and the 2nd AAAS-Socio-Psychological Prize, to Herbert C. Kelman, research psychologist, National Institute of Mental Health [*Science* **125,** 60 (1957)].

RAYMOND L. TAYLOR
Associate Administrative Secretary

APPLICATIONS SOLICITED FOR TRAVELING LIBRARY PROGRAM

The Traveling High School Library Program, supported by a grant from the National Science Foundation and administered by the AAAS, is now making plans for the academic year 1957–58. A description of the 1956–57 program and a list of the 200 books in the traveling libraries presently serving 104 senior high schools have been published [*Science* **124,** 1013 (1956); *Sci. Monthly* **83,** 300 (1956)].

During 1957–58 it is hoped that the program will be extended to approximately 300 senior high schools which will receive 50 books at a time in traveling cases. Each school will exchange books with other program schools at intervals of 2 months, so that every school will have had an opportunity to use all 200 books in the traveling library during the year.

The program is intended to increase the interest of high-school students in science, to encourage the choice of careers in science, and to broaden the science and mathematics background of high-school teachers. The program also serves to stimulate the acquisition of well-chosen science books for school and public libraries.

The greatest apparent need for this program is in small and medium-sized high schools in nonmetropolitan localities that lack good community library facilities. The following general criteria will guide the selection of about 300 program schools for the next year: (i) the school should have an enrollment of at least 150 but not more than 750 students in the 10th to 12th grades, inclusive; (ii) good community library services should not be readily accessible to the students at the school; (iii) the school should have a library and employ a school librarian.

The principals of public and private high schools or preparatory schools interested in receiving additional information and application blanks are requested to write immediately to Dr. Hilary J. Deason, American Association for the Advancement of Science, 1515 Massachusetts Ave., NW, Washington 5, D.C. The final date for the receipt of formal applications for the 1957–58 program is 15 May. Priority of receipt of application will be a factor in school selection.

BOOK REVIEWS

A Life of Sir William Ramsay. Morris W. Travers. Edward Arnold, London, 1956. 308 pp. Illus. $12.50.

When William Ramsay was a young student at the University of Glasgow, he wished to study chemistry but was reportedly advised not to, "for it provided no future prospects, as this subject was played out." The adviser (a well-known chemist who will not be mentioned here) headed a department that gave only a single course of lectures, intended primarily for medical students. Germany was then the mecca of chemists, and thither Ramsay went to begin his career in 1871.

In his later years, Ramsay was in the thick of the early work on radioactivity—in fact, he lived to speculate publicly on the explosive effect that would result from a sudden evolution of the energy of radioactive elements. The 40-odd years of his scientific career covered, therefore, a sizable part of the history of chemistry, and the biography of a chemist with Ramsay's wide acquaintance is a document of some importance in that history.

Ramsay's part in the discovery of the rare gases has long since been told in unusual detail, by several authors, including Travers, for this has been regarded as one of the most romantic episodes in chemistry. The discovery of an "immense collection" of additional materials in the legacy of Lady Ramsay led Travers to take up the subject again, to attempt "an analytical study of Ramsay's work in the field of science and in that of education." In so doing, he casts new light on such rarely illuminated aspects of the process of scientific discovery as the sources of inspiration, the interaction of parallel investigations, and the influence of coincidental events. Rarely has a scientific event been so closely scrutinized as here. The picture of the problems of the experimentalist in the 1880's and 1890's, such as that of Ramsay searching the London shops for his raw materials, should also make thought-provoking reading for the scientist of today.

A unique opportunity for a thoroughly penetrating study of the process of discovery has been made possible, not only by the voluminous records available, but by the author's familiarity with the subject, as Ramsay's associate and as codiscoverer of neon, krypton, and xenon. Travers deserves much credit for carrying the project to completion in his 83rd year, despite ill health and other difficulties. For once we do not have to say, "If only the participants had written what they knew of those great events." In honoring further the illustrious chemist with whom he worked in his youth, Travers does no less honor to himself.

ROBERT MULTHAUF

Smithsonian Institution

Science and Civilisation in China. vol. 2, *History of Scientific Thought.* Joseph Needham. Wang Ling, research assistant. Cambridge University Press, New York, 1956. 696 pp. Illus. $14.50.

Those who have read the first volume of this monumental series (six volumes projected), in which the author presents the plan of the work, gives notes on the bibliography, surveys the history of China and its connections with the West, and includes a sketch of the Chinese language, will not have to be told that this second volume is a work of great importance. Those who have not read the first volume are urged to do so if they feel any interest in the civilization of China and in Chinese contributions to science and the technical arts. It is probably not essential to read volume 1 before undertaking volume 2, but it would certainly be wise to do so.

It is difficult to give any adequate idea of the immense scope of the present work. Not only are the principal philosophic writings of China, from all periods of its history, discussed, but they are compared with the corresponding works produced at the same time in the West. In general, there seem to be three major themes: the works of the Taoists, of the Confucianists, and of the Buddhists. One has the impression that this is the most profound study of the main currents of Chinese thought that has been published in a Western language for a long time—perhaps the most profound that has ever been published.

Joseph Needham considers in great detail the effect of each of these systems of thought, and their interactions, on the development of science in China—although the full treatment of Chinese science is to be deferred to a later volume—and ponders the question: Why did China, although for a long time ahead of the West in civilization, not evolve a science comparable to that developed in Europe during the 18th and 19th centuries? He also asks: Could Europe have had this development without its background of the Judeo-Chris-

tian idea of divine law? He does not really answer the second question, and his answer to the first is not easy to summarize. His conception of the answer, given as nearly as possible in his own words, is this: The Chinese acquired a great distaste for precisely formulated, codified law during the period of transition from feudalism to bureaucracy; the Chinese concept of law was overwhelmingly social and ethical, making extension of it to nonhuman nature impossible; and the Chinese concept of a supreme being early lost the qualities of personality and creativity, so that this being could not be looked upon as the Giver of the laws of nature.

There are a number of surprising things in the book. For example, Buddhism, which many consider one of the noblest of the major religions, is treated by Needham as a mere tissue of superstitions. It is only fair to point out that he treats all other religions in the same way. But some features are even more surprising. I have always agreed with Bertrand Russell that the philosophy of Hegel is the sheerest twaddle, not to mention the social applications (or misapplications) of it by Marx and Engels. It is therefore disconcerting to find the writings of the latter two authors referred to repeatedly as one of the highest peaks of Western thought. This gives rise to the uncomfortable suspicion: If Needham's interpretation of Western intellectual history differs so much from that of some, at least, of his readers, how do we know that his interpretation of Chinese thought does not suffer from an equal or greater bias? It is to be feared that, until somebody writes another equally comprehensive book about China, Western readers are going to find it hard to answer this question. Meanwhile *Science and Civilisation in China* will probably continue to tower for a long time—a sort of *Zauberberg* of learning.

WILLIAM C. BOYD
Boston University School of Medicine

Biological Treatment of Sewage and Industrial Wastes. vol. I, **Aerobic Oxidation.** Brother Joseph McCabe and W. W. Eckenfelder, Jr., Eds. Reinhold, New York; Chapman and Hall, London, 1956. 393 pp. Illus. $10.

The 33 papers that were given at a conference on Biological Waste Treatment, held at Manhattan College in April 1955, are presented in this symposium-type volume. The papers are grouped into four parts: part 1 gives the theory of treatment of wastes by biological means; part 2 is concerned with design for provision of aeration; part 3 is concerned with the treatment of sewage; and part 4 describes the treatment of industrial wastes.

The book presents fundamental concepts of waste disposal and gives realistic methods for accomplishing this end. The papers are presented by experts in the field and in a logical sequence. A bibliography of original sources is given, as appropriate, after each of the four parts. The book represents a sound scientific approach to an important practical problem.

I. E. WALLEN
AAAS Science Teaching Improvement Program

A Space Traveler's Guide to Mars. I. M. Levitt. Holt, New York, 1956. 175 pp. Illus. + plates. $3.95.

I. M. Levitt is certain that not only will vehicles for space travel become a certainty in the future but that many of the readers of his book will themselves take part in expeditions to Mars. He has prepared a guidebook for the expeditions, and it is far more readable than most of the guidebooks that are intended for terrestrial travelers.

The book covers much more than a guidebook usually would. In the early chapters, techniques of space travel and the initial space exploration of Mars are described, but in the middle of the book the emphasis is taken away from space exploration to a straightforward account of the characteristics of the surface and atmosphere of the planet.

The types of animal and vegetable life that could exist on Mars are the subject of a short chapter. The final part of the book discusses the origin of the universe, the evolution of the solar system, and the interesting philosophic question of the existence of life elsewhere in the universe. There are two appendixes, one concerned with time and calendar matters, the other with possible chemical mechanisms for the beginning of life on the earth. A bibliography, a glossary of terms, and an index add to the usefulness of the book.

Levitt's book has a large number of references to very recent work by current astronomers, such as Kuiper, McLaughlin, and de Vaucouleurs, as well as an interesting amount of historical material, some of which is certain to be new to many of the intended readers. The text moves along rapidly and is highly readable. The facts and figures are there, but we are not overburdened by them, as we so often are when specific astronomical results are described in popular writing.

This book will be used largely by the amateur astronomer and by the high-school student who is

interested in bringing himself up to date on the exploration of Mars. It is apparently not intended to be used by serious university students, but many students in introductory courses in astronomy will find it a useful supplement to the usual textbooks.

ROBERT FLEISCHER
Observatory of Rensselaer Polytechnic Institute and *Dudley Observatory*

The Earth We Live On. The story of geological discovery. Ruth Moore. Knopf, New York, 1956. x + 416 pp. Illus. $6.

This book, written by a newspaperwoman who evidently has never had any formal training in geology, is intended primarily for the layman interested in earth science and earth history. It attempts to trace the development of geologic ideas from the very beginnings of mythological times to the present day.

The subtitle proclaims the book to be "the story of geological discovery." What the author undoubtedly means is that it is the story of the evolution of geologic concepts through discovery. In this respect, the general aim of the book is attained far more successfully than the first chapters would lead the reader to expect. In fact, I feel that the first two chapters mar the quality of the book and could very well have been left out. The second chapter, especially, may be confusing to the uncritical reader, if not actually misleading. To the uninitiated it might appear, here, that the author is presenting evidence in proof of the Biblical flood of Noah's time.

The Earth We Live On takes the reader from the early phases of geologic thought, with the attendant controversy over Biblical dogma versus deductions from observable field evidence, through the painful and slow development of current geologic ideas down to modern times, and ends with some of the latest theoretical derivations of the last few years. The book guides him through the relatively simple, early interpretations of observable phenomena and through the theoretical thinking that helps build up the *why* and *wherefore* of these observed phenomena. From this point it leads into the realms of geochemistry and geophysics and to speculations and assumptions about the earth's inner structures. Ruth Moore seems to be fascinated by theories concerning the interior of our planet.

Moore presents each new step in the development of geologic ideas through a brief discussion of the lives and findings of key individuals who were largely responsible for the gradual evolution of modern geologic thought. She gives credit to Jean Etienne Guettard as the founder of modern geologic philosophy. Step by step, she shows how the following persons contributed to the evolution of present-day geologic concepts: Nicolas Demarest, Abraham Gottlob Werner, James Hutton, Georges Cuvier, Louis Agassiz, Charles Lyell, William Logan, James Hall, John Wesley Powell, Clarence E. Dutton, Thomas C. Chamberlin, Harold Clayton Urey, Harold Jeffreys, Edward C. Bullard, Stanley Keith Runcorn, J. Tuzo Wilson, Aaron C. Waters, V. M. Goldschmidt, Brian Mason, Ernest Rutherford, and J. Laurence Kulp. The choice is well thought out and no doubt was influenced by competent advice. A number of these names are not primarily associated with the earth sciences, and a professional earth-scientist writing along the same lines would probably have left out a few and included others, but most of the names would have to remain, for these are the men who made the basic contributions to geology.

There is considerable naïveté in the writing. This is understandable in view of the fact that Moore is an amateur who merely makes the study of earth science her hobby. Also, for the same reason, her selection of ideas for discussion may, in some instances, be open to question. Concepts which strike her fancy are apparently accepted as gospel. Too often she takes controversial ideas or hypotheses at their face value, without entertaining any doubts. She is sometimes given to fanciful flights of imagination, which the average non-specialist would have trouble detecting, since she writes with considerable conviction.

Nevertheless, in spite of errors, this book will be of value not only to the layman who is interested in reading about the earth but also to students of geology (and to their teachers). It is a useful quick-reference book and contains much information of interest even to the busy geologist who does not find time to keep abreast of all new material published in his field (and this applies to virtually all geologists). The layman may find it obscure, at times, for technical terms are occasionally used without adequate definition.

An index is included, but it is far from complete. A far more serious failing, from the standpoint of the researcher, is the lack of footnote documentation. Much material is included within quotation marks in the body of the text, but rarely is the source given in a footnote. Students seeking fuller information would have difficulty locating the material at its source.

JULIUS KAIKOW
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On Freedom and Free Enterprise. Essays in honor of Ludwig von Mises. Presented on the occasion of the fiftieth anniversary of his doctorate, February 20, 1956. Mary Sennholz, Ed. Van Nostrand, Princeton, N. J., 1956. 333 pp. $3.50.

Ludwig von Mises is a product of the famous 19th century Austrian school of economics and is one of its distinguished 20th century representatives. Mises is noted above all for his uncompromising opposition to socialism and to all forms of government intervention that distort the operation of the price system. As early as 1920 he forecast the economic weakness of socialism; its rejection of the free-market mechanism denied it the means of calculating cost and return essential to a rational allocation of economic resources. Events have largely vindicated his economic and sociologic analysis of socialism; confirmation comes from even the upper echelons of communism. Yet Mises is not popular. His intransigeance repels many who incline toward a more moderate version of his position. And those of a different persuasion have large investments of emotional and intellectual capital in the cause of interventionism.

Mises earned his doctorate from the University of Vienna in 1906. The present volume is dedicated to the 50th anniversary of that event. Nineteen authors from seven countries have contributed essays.

The first essays (part I) are extravagant in their praise of Mises, particularly of his more extreme views. A greater service would have been rendered by a thoughtful review of his principal contributions to economics and sociology. Part II, "On the nature of man and government," can be lightly read.

Part III, on "Scientific method," holds much of interest. Wilhelm Röpke (Switzerland) ranges widely over the methodological problems in economics. These concern him. Economic theorists tend too often to neglect the importance of judgment, good sense, and the keen, intuitive sense of reality essential to an understanding of economic problems. They tend "to cede their position to a formalistic facility in the manipulation of methods which have been unwarrantably adopted from the natural sciences . . . ." (p. 120). Undue emphasis on mathematics, model building, and mechanistic Keynesian aggregates diverts economists from the main point: economics is one of the *Geisteswissenschaften,* with the market as the means of translating subjective feelings into objective, measurable actions. Röpke sees economics tending toward impersonalization, collectivization, mechanization, and dehumanization. But in that it is not alone; Picasso and Keynes, each in his own field, reflect the trend. In a similar vein, Louis M. Spadaro's essay, "Averages and aggregates in economics," points to the limitations of these measurements. Excessive reliance on such measurements removes the causative in human action, eliminates differences, and reduces human action to the "average." As government control increases, more averages are needed as tools of control. One control leads to another, and each average is averaged into another. This might be behind Parkinson's law, but the thought is too light for Spadaro's serious essay. He does link socialism with the "averaging" process; the "average" is the end in that system.

Fritz Machlup's "The inferiority complex of the social sciences" wisely and loftily pokes fun at the narrow-minded pretensions of the frustrated and quarrelsome devotees of an assortment of methodological positions, each claiming his own to be *the* scientific method. Frustration arises from the guilty belief that the natural sciences have a monopoly of scientific method. But Machlup exhibits no methodological frustration; *Wissenschaft* holds no discrimination. Moreover, "the student of human action is himself an acting human being" and thus has a source of knowledge denied the physical scientist.

In part IV, Murray Rothbard's "Toward a reconstruction of utility and welfare economics" is a serious attempt to rescue welfare economics through the "demonstrated preference" approach. F. A. Hayek's "Progressive taxation reconsidered" (part V) reveals how radical a conservative position can become. Other contributions in this section leave the same impression.

The volume closes "On socialism." Louis Baudin describes the intellectual bankruptcy of French socialism and the sentimental attachment of a rational people to an irrational cause. Mises can well say he saw all this decades ago—and he did.

ARTHUR E. BURNS
George Washington University

The Old Stone Age. A study of palaeolithic times. Miles C. Burkitt. New York University Press, New York, ed. 3, 1956. viii + 258 pp. Illus. $3.75.

This is a textbook for beginners in prehistoric archeology. The first six chapters are concerned with methods of study and with description of technical terminology and geologic problems. One chapter, in fact, lists the various tool-families alpha-

betically, for convenient reference, and a later chapter gives some hints for the student who is engaged in the various kinds of field work involved in the study of the life and times of our remote European ancestors.

In presenting archeological content and interpretation, the author limits himself almost exclusively to Europe. The time span starts with the earliest evidence of human culture, which Burkitt puts early indeed. He states that "while the existence of tertiary man seems incontestable many problems remain to be elucidated. So far the evidence rests solely on the occurrence of chipped flints which in some cases satisfy the criteria for human workmanship."

Much more definite information obtains for Quaternary times, although the evidence is complex. Certain broad lines of cultural development emerge. In the early Pleistocene, a flake-tool culture (Cromerian) seemingly has priority in Europe. Later, a core-tool civilization, spreading up from Africa, swept the board in western Europe, leaving the area east of the Rhine to flake-tool makers. When, however, the core-tool makers retired from the scene at the maximum of the last glaciation, the flake-tool cultures occupied the whole area. Then the upper paleolithic cultures appear and differ markedly from those that had preceded them. A more modern type of man comes on the scene, and new tool types are introduced from outside, thus increasing the variety of artifacts. The author emphasizes particularly the dramatic development of art in this period, devoting a chapter to the so-called "home art," another to the famous cave paintings, and a third to the rock-shelter art of eastern Spain. The casual reader may find the most interesting section to be the discussion of possible motives underlying the production of these several types of artistic expression.

REGINA FLANNERY HERZFELD
Catholic University of America

The World of Mathematics. A small library of the literature of mathematics from A'h-mose the Scribe to Albert Einstein, presented with commentaries and notes by James R. Newman. 4 vols. Simon and Schuster, New York, 1956. 2535 pp. Illus. $20.

"Books are to be read" is not literally true for the four volumes of *The World of Mathematics.* These are books to be owned, enjoyed, dipped into, referred to, and returned to often but not read through as one reads a novel. The compression of thought evident in any good mathematical writing makes such "reading through" impossible. Accordingly, I did not read them through either but looked for organization, selection, and style.

The selections chosen determined the organization of these books. This makes the organization more useful than logical. The 26 parts (containing 133 selections by 113 authors) deal with the relation between mathematics and such topics as space and motion, the physical world, the social sciences, laws of chance, statistics, logic, warfare, esthetics, ethics, and music. There is emphasis on the historical-biographical aspect of mathematics, and some of the amusing puzzles based on mathematics are included. The fallacy of the "great books" approach has been avoided: historical selections, which are almost always more difficult to understand than more polished, modern explanations of the same thing, are few in number and include only important excerpts. Nevertheless, the books would have been incomplete without such original writings as those of Plutarch, Recorde, Descartes, Berkeley, Archimedes, Newton, Dedekind, Euler, Galileo, Daniel Bernoulli, Galton, Malthus, Laplace, Jakob Bernoulli, and Lewis Carroll.

Every real student is a potential anthologist: he wants to share his delights with his friends. Anyone working in mathematics has a list, written or mental, of selections that should be passed on to others. Newman's collection is challenged by a comparison with all these lists, organized and ephemeral. I suspect that every mathematician who makes such a comparison will be amazed to find the large number of his favorites that have been included. Indeed, this fact makes such a compilation as this possible; many of the selections have been read previously. The reader does not resent this, for many of the books, although familiar, are not in his library, and it is pleasant to know that they are now within easy reach. Of course, each person will find some favorites missing, but the editor has avoided this criticism by admitting, in the introduction, the unavoidable inadequacies of any anthology.

In general, the collection is *"about* mathematics," not strictly "mathematics." This is not a criticism but a word to the reader, to let him know what to expect. It is lucky that so many first-rate mathematicians have had the time to write about their subject. But not all the selections are by mathematicians. In addition to Russell, Whitehead, Courant, Weyl, Menger, Schrödinger, Heisenberg, Eddington, Poincaré, Fisher, Veblen,

Polya, Hardy, von Neumann, Birkhoff, and Jeans, we find such unexpected names as Jonathan Swift, Aldous Huxley, George Bernard Shaw, and Stephen Leacock.

There are pertinent commentaries by the editor, who combines wit with an impressive background of knowledge. The attractiveness of these connecting passages and the excellence of the selections often whet the appetite for more of the work from which the articles are taken. This discloses one of the weaknesses of the anthology: it is often difficult to determine from what source the selection *is* taken, what fractional part is being presented in this particular anthology, and the place and date of the most accessible edition of the complete work. Admittedly, too many footnotes defeat their own purpose; but why not a list at the end of each volume for those who have a particular interest and wish to keep going? For example, how much more is there to *A Mathematician's Apology* by G. H. Hardy, and where is it to be found?

Physically, the books are sturdy and attractive, with clear type face and simple design. Perhaps it is too much to ask for paper that would reproduce halftones clearly when there are so few, but some (for example, in the chapters on "Mathematics of space and motion") are below minimum standards. All line drawings are very clear.

The index covers 65 pages and adds greatly to the value of this collection for reference purposes.

This set of books has already sold well. It reminds one of the popularity of another book published about 20 years ago: *Mathematics for the Million*. The sales of both books are a practical indication to all teachers of mathematics, and to all mathematicians, that their subject is fundamentally respected, admired, and even liked, regardless of the attitude of uninterest that many people assume. There is a danger that the popular title of these volumes will attract those who are eager for an easy understanding of a subject they know to be important. Unfortunately, if the material is important it can be understood only by thinking about it; and thinking always involves work. For those who are willing to be patient, read slowly, think, and work, these books offer the most concentrated, important, and inexpensive library of mathematics now available.

HENRY W. SYER

Boston University

Books Reviewed in SCIENCE

1 February

The World of Mathematics, J. R. Newman, Ed. and compiler (Simon & Schuster). Reviewed by J. R. Mayor.

The Nature of Brucellosis, W. W. Spink (Univ. of Minn. Press). Reviewed by K. F. Meyer.

Chazyan and Related Brachiopods, G. A. Cooper (Smithsonian Inst.). Reviewed by C. E. Prouty.

Observations on Krebiozen in the Management of Cancer, A. C. Ivy, J. F. Pick, W. F. P. Phillips (Regnery). Reviewed by C. P. Rhoads.

The Menninger Story, W. Winslow (Doubleday). Reviewed by B. C. Hendricks.

8 February

Protozoologie, K. G. Grell (Springer). Reviewed by G. H. Ball.

Physics, Psychology and Medicine, J. H. Woodger (Cambridge Univ. Press). Reviewed by E. Nagel.

Glaucoma, F. W. Newell, Ed. (Josiah Macy, Jr., Foundation). Reviewed by L. C. Moss.

Advances in Carbohydrate Chemistry, M. L. Wolfram and R. S. Tipson, Eds. (Academic Press). Reviewed by H. Gehman.

Features of Evolution in the Flowering Plants, R. Good (Longmans, Green). Reviewed by R. W. Holm.

22 February

Atomic Energy for Your Business, A. Kramish and E. M. Zuckert (McKay). Reviewed by D. H. Loughridge.

Automatic Digital Calculators, A. D. Booth and K. H. V. Booth (Academic Press). Reviewed by J. Rothstein.

Diseases of the Skin, R. L. Sutton, Jr. (Mosby). Reviewed by L. H. Warren.

Beiträge zur Geschichte der Erkenntnis des Erdmagnetismus, H. Balmer (Sauerländer). Reviewed by B. Gutenberg.

Progress in Cosmic Ray Physics, J. G. Wilson, Ed. (North-Holland; Interscience). Reviewed by S. F. Singer.

Recent Progress in Hormone Research, G. Pincus, Ed. (Academic Press). Reviewed by J. T. Velardo.

Vitamins and Hormones, R. S. Harris, G. F. Marrian, K. V. Thimann (Academic Press), Reviewed by J. T. Velardo.

Principles of Color Television, K. McIlwain and C. E. Dean, Eds. (Wiley; Chapman & Hall). Reviewed by W. T. Wintringham.

New Books

Handbuch der Physik. vol. XV. *Low Temperature Physics* II. S. Flügge, Ed. Springer, Berlin, 1956. 477 pp.

Contributions a l'Etude des Parasites et Phorétiques de Coléopteres Terrestres. Supplement No. 4 to *Vie et Milieu*. Jean Théodorides. Hermann, Paris, 1955. 310 pp. F. 1500.

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Engineering Uses of Rubber. A. T. McPherson and Alexander Kemlin. Reinhold, New York; Chapman & Hall, London, 1956. 490 pp. $12.50.

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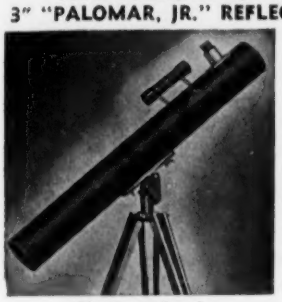

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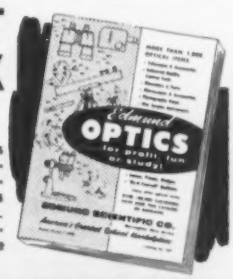

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Meetings

April

24–25. Industrial Research Conf., Chicago, Ill. (C. E. Barthel, Armour Research Foundation, Illinois Inst. of Technology, 10 W. 35 St., Chicago 16.)

24–26. Purity Control by Thermal Analysis, IUPAC, Amsterdam, Netherlands. (W. M. Smit, Central Inst. for Physico-Chemical Constants, Biltstraat 172, Utrecht, Netherlands.)

24–26. Sanitary Engineering Conf. on Solids Handling and Anaerobic Digestion, New York, N.Y. (W. W. Eckenfelder, Jr., Civil Engineering Dept., Manhattan College, New York 71.)

24–27. Plant Quality, 2nd internatl. colloquium, Paris, France. (L. Genevois, Faculté des Sciences, Université de Bordeaux, 20, Cours Pasteur, Bordeaux, France.)

25–26. Institute of Environmental Engineers, 1st annual tech. conf., Chicago, Ill. (G. D. Wilkinson, IEE, 9 Spring St., Princeton, N.J.)

25–26. Midwest Benthological Soc., annual, Urbana, Ill. (A. Lopinot, 205 W. Osie, Gillespie, Ill.)

25–27. West Virginia Acad. of Science, annual, Keyser. (M. Ward, Glenville State College, Glenville, W. Va.)

25–29. Pan American Cancer Cytology Cong., Miami, Fla. (J. E. Ayre, New York Univ., New York, N.Y.)

26–27. Alabama Acad. of Science, annual, Jacksonville. (H. A. McCullough, Dept. of Biology, Howard College, Birmingham, Ala.)

26–27. American Assoc. of University Professors, annual, New York, N.Y. (R. F. Fuchs, AAUP, 1785 Massachusetts Ave., NW, Washington 6.)

26–27. Iowa Acad. of Science, annual, Cedar Falls. (J. L. Laffoon, Dept. of Zoology and Entomology, Iowa State College, Ames.)

26–27. Kentucky Acad. of Science, Mammoth Cave. (G. Levey, Berea College, Berea, Ky.)

26–27. Mississippi Academy of Sciences, annual, Columbus. (C. Q. Sheely, State College, Miss.)

26–27. Montana Acad. of Sciences, 17th annual, Billings. (L. H. Harvey, Montana State Univ., Missoula.)

26–27. South Dakota Acad. of Science, annual, Sioux Falls. (J. M. Winter, Botany Dept., Univ. of South Dakota, Vermillion.)

26–28. Cooper Ornithological Soc., annual, Los Angeles, Calif. (J. Davis, Hastings Reservation, Jamesburg Route, Carmel Valley, Calif.)

27–2. Scientific Apparatus Makers Assoc., 39th annual, White Sulphur Springs, W. Va. (SAMA, 20 N. Wacker Dr., Chicago 6, Ill.)

28. American Soc. of Hospital Pharmacists, New York, N.Y. (Mrs. G. N. Francke, 1812 Norway Rd., Ann Arbor, Mich.)

28–30. American Assoc. of Colleges of Pharmacy, annual, New York, N.Y. (G. L. Webster, Univ. of Illinois College of Pharmacy, 808 S. Wood St., Chicago 12.)

28–2. Southwestern and Rocky Mountain Division–AAAS, annual, Tucson, Ariz. (F. E. E. Germann, 1800 Sunset Blvd., Boulder, Colo.)

28–3. American Pharmaceutical Assoc., annual, New York, N.Y. (R. P. Fischelis, APA, 2215 Constitution Ave., NW, Washington 7.)

28–3. Soc. of American Bacteriologists, annual, Detroit, Mich. (J. H. Bailey, Sterling-Winthrop Research Inst., Rensselaer, N.Y.)

29–30. National Assoc. of Boards of Pharmacy, annual, New York, N.Y. (P. H. Costello, NABP, 77 W. Washington St., Chicago 2, Ill.)

29–1. American Assoc. of Spectrographers, 8th annual, Chicago, Ill. (T. H. Zink, H. Cohn & Sons, 4528 W. Division St., Chicago 51.)

29–1. American Geophysical Union, 38th annual, Washington, D.C. (W. E. Smith, AGU, 1515 Massachusetts Ave., NW, Washington 5.)

29–1. American Oil Chemists' Soc., 48th annual, New Orleans, La. (R. T. O'Connor, Southern Regional Research Laboratory, New Orleans.)

29–2. Flight Test Instrumentation Symp., 3rd annual, Los Angeles, Calif. (E. Spencer, Los Angeles Section, Instrument Soc. of America, 5225 Wilshire Blvd., Los Angeles 36.)

29–2. International Acad. of Proctology, 9th annual, New York, N.Y. (A. J. Cantor, IAP, 147–41 Sanford Ave., Flushing 55, L.I.)

29–4. Irrigation and Drainage, 3rd internatl. cong., San Francisco, Calif. (W. E. Blomgren, 260 Leetsdale Dr., Denver 22, Colo.)

30–1. Metal Powder Assoc., 13th annual, Chicago, Ill. (MPA, 130 W. 42 St., New York 36.)

May

1–2. Image Formation and Measurement with Electronic Techniques, symp., Boston, Mass. (F. Brech, 26 Farwell St., Newtonville, Mass.)

1–3. Electronic Compounds Conf., Chicago, Ill. (R. M. Soria, 1830 S. 54 Ave., Chicago 50.)

1–3. Society for Experimental Stress Analysis, spring, Boston, Mass. (W. M. Murray, SESA, P.O. Box 168, Cambridge 39, Mass.)

2–4. American Philosophical Assoc., annual, Chicago, Ill. (W. H. Hay, Bascom Hall, Univ. of Wisconsin, Madison 6.)

2–4. Animal Disease and Human Health Conf., New York, N.Y. (Mrs. E. T. Miner, New York Acad. of Sciences, 2 E. 63 St., New York 21.)

2–4. Illinois State Acad. of Science, annual, Normal. (R. A. Evers, Illinois Natural History Survey, Urbana.)

2–4. Kansas Acad. of Science, annual, Manhattan. (C. T. Rogerson, Dept. of Botany, Kansas State College, Manhattan.)

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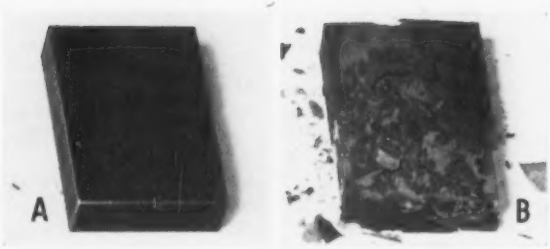

(Photo A) Kentanium shows only slight oxidation after test and is good for many more hours' exposure at 2000°F. (Photo B) Hard nickel-chromium (35%) alloy is badly oxidized and began to disintegrate during test.

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2–4. Midwestern Psychological Assoc., annual, Chicago, Ill. (D. W. Fiske, Dept. of Psychology, Univ. of Chicago, Chicago 37.)

2–5. Society for American Archaeology, annual, Madison, Wis. (D. A. Baerreis, Dept. of Sociology and Anthropology, Univ. of Wisconsin, Madison 6.)

3. Engineers and Architects Conf., 4th annual, Columbus, Ohio. (G. B. Carson, College of Engineering, Ohio State Univ., Columbus 10.)

3–4. Minnesota Acad. of Science, Rochester. (B. O. Krogstad, Univ. of Minnesota, Duluth 5B.)

3–4. North Carolina Acad. of Science, annual, Winston-Salem. (J. A. Yarbrough, Meredith College, Raleigh, N.C.)

3–4. North Dakota Acad. of Science, annual, Grand Forks. (B. G. Gustafson, Chemistry Dept., Univ. of North Dakota, Grand Forks.)

3–9. Food Additives, 3rd symp., Como, Italy. (International Bureau of Analytical Chemistry of Human and Animal Food, 18, avenue de Villars, Paris 73, France.)

4–5. American Psychosomatic Soc., 14th annual, Atlantic City, N.J. (I. A. Mirsky, APS, 551 Madison Ave., New York 22.)

4–5. Population Assoc. of America, annual, Philadelphia, Pa. (D. O. Price, Inst. for Research in Social Science, Univ. of North Carolina, Chapel Hill.)

5–9. American Ceramic Soc., 59th annual, Dallas, Tex. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

5–10. International Cong. of Otolaryngology, 6th, Washington, D.C. (P. H. Holinger, 700 N. Michigan Ave., Chicago 11, Ill.)

7. International Hydrographic Conf., 7th, Monte Carlo, Monaco. (International Hydrographic Bureau, Quai des Etats-Unis, Monte Carlo.)

7–24. World Health Assembly, 10th, Geneva, Switzerland. (World Health Organization, Palais des Nations, Geneva.)

8–9. European Federation of Chemical Engineering, 12th, Amsterdam, Netherlands. (Federation, Frankfurt/Main, Germany.)

8–11. American Astronomical Soc., Cambridge, Mass. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38.)

8–11. American Helicopter Soc., 13th annual, Washington, D.C. (H. M. Lounsbury, AHS, 2 E. 64 St., New York 21.)

9. Dietary Essential Fatty Acids, Assoc. of Vitamin Chemists, Chicago, Ill. (M. Freed, Dawe's Laboratories, Inc., 4800 S. Richmond St., Chicago 32.)

9–10. Microwave Ferrites and Related Devices and Their Applications, New York, N.Y. (S. Weisbaum, Bell Telephone Laboratories, Murray Hill, N.J.)

9–10. Operations Research Soc. of America, 5th annual, Philadelphia, Pa. (M. L. Ernst, P.O. Box 2176, Potomac Sta., Alexandria, Va.)

9–11. Virginia Acad. of Science, Old Point Comfort. (F. F. Smith, Box 1420, Richmond, Va.)

9–12. American Psychoanalytic Assoc., Chicago, Ill. (J. N. McVeigh, APA, 36 W. 44 St., New York 36.)

10–11. Indiana Acad. of Science, Turkey Run State Park, (H. Crull, Dept. of Mathematics, Butler Univ., Indianapolis 1, Ind.)

12–13. International Soc. of Bronchoesophagology, cong., Philadelphia, Pa. (C. L. Jackson, 1901 Walnut St., Philadelphia 3.)

12–16. Electrochemical Soc., Washington, D.C. (H. B. Linford, 216 W. 102 St., New York 25, N.Y.)

12–16. Institute of Food Technologists, annual, Pittsburgh, Pa. (C. S. Lawrence, IFT, 176 W. Adams St., Chicago 3, Ill.)

13–15. Radiation Research Soc., annual, Rochester, N.Y. (A. Adelmann, Nuclear Science and Engineering Corp., P.O. Box 10901, Pittsburgh 36, Pa.)

13–15. Recent Developments in Research Methods and Instrumentation, symp., Bethesda, Md. (J. A. Shannon, National Institutes of Health, Bethesda.)

13–15. Structure of Electrolytic Solutions, NSF symp., Washington, D.C. (H. B. Linford, Electrochemical Soc., 216 W. 102 St., New York 25.)

13–16. Semiconductor Symp., 5th annual, Washington, D.C. (H. M. Pollack, Semiconductor Div., RCA, 415 S. 5 St., Harrison, N.J.)

13–17. American Psychiatric Assoc., annual, Chicago, Ill. (D. Blain, APA, 1785 Massachusetts Ave., NW, Washington 6.)

14–16. International Soc. of Audiology, cong., St. Louis, Mo. (S. R. Silverman, 818 S. Kingshighway, St. Louis 10.)

15–16. Space Age Symp., Southern Research Inst., Birmingham, Ala. (R. D. Osgood, Jr., Southern Research Inst., 917 S. 20 St., Birmingham 5.)

16–18. Engineering Industries Exposition, New York, N.Y. (H. Becher, New York State Soc. of Professional Engineers, 1941 Grand Central Terminal, New York 17.)

17. Maryland Acad. of Sciences, annual, Baltimore. (T. King, Maryland Acad. of Sciences, Enoch Pratt Free Library Bldg., Baltimore 1.)

17–19. American Inst. of Industrial Engineers, 8th annual, New York, N.Y. (J. L. Southern, AIIE, 145 N. High St., Room 303, Columbus 15, Ohio.)

19–23. American Assoc. of Cereal Chemists, annual, San Francisco, Calif. (C. L. Brooke, Merck & Co., Inc., Rahway, N.J.)

19–24. National Conf. on Social Welfare, annual, Philadelphia, Pa. (F. Schmidt, NCSW, 22 W. Gay St., Columbus 15, Ohio.)

20–21. Society of American Military Engineers, annual, Washington, D.C. (National Headquarters, SAME, 808 Mills Bldg., Washington 6.)

20–22. International Voice Conf., Chicago, Ill. (H. Von Leden, 30 N. Michigan Ave., Chicago 2.)

20–24. Mass Spectrometry, New York, N.Y. (R. A. Friedel, U.S. Bureau of Mines, 4800 Forbes St., Pittsburgh 13, Pa.)

20–25. International Conf. of Epizootics, annual, Paris, France. (12, rue de Prony, Paris 17e.)

20–31. International Federation of Agricultural Producers, 9th general assembly, Lafayette, Ind. (IFAP, 712 Jackson Pl., NW, Washington, D.C.)

22–24. American Inst. of Chemists, annual, Akron, Ohio. (L. Van Doren, AIC, 60 E. 42 St., New York 17.)

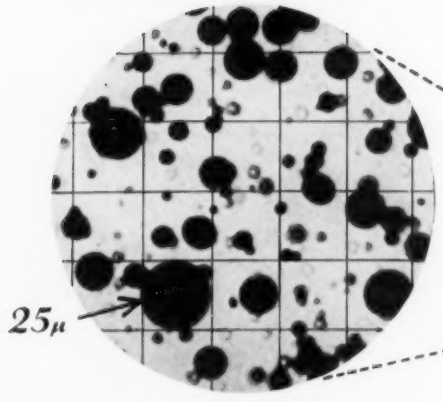
22–24. American Soc. for Quality Control, annual, Detroit, Mich. (L. S. Eichelberger, A. O. Smith Corp., Milwaukee 1, Wis.)

22–25. International Scientific Radio Union, natl. spring meeting, Washington, D.C. (J. P. Hagen, USA National Committee URSI, National Acad. of Sciences, 2101 Constitution Ave., NW, Washington 25.)

23–25. Acoustical Soc. of America, New York, N.Y. (W. Waterfall, ASA, 57 E. 55 St., New York 22.)

25–26. International Cong. for the Study of the Bronchi, Lisbon, Portugal. (F. Lopo de Carvalho, 138, rua de Junqueira, Lisbon.)

25–28. International Cong. of Acupuncture, 9th, Vienna, Austria. (Austrian Assoc. for Acupuncture, 57 Schwenderstrasse, Vienna.)



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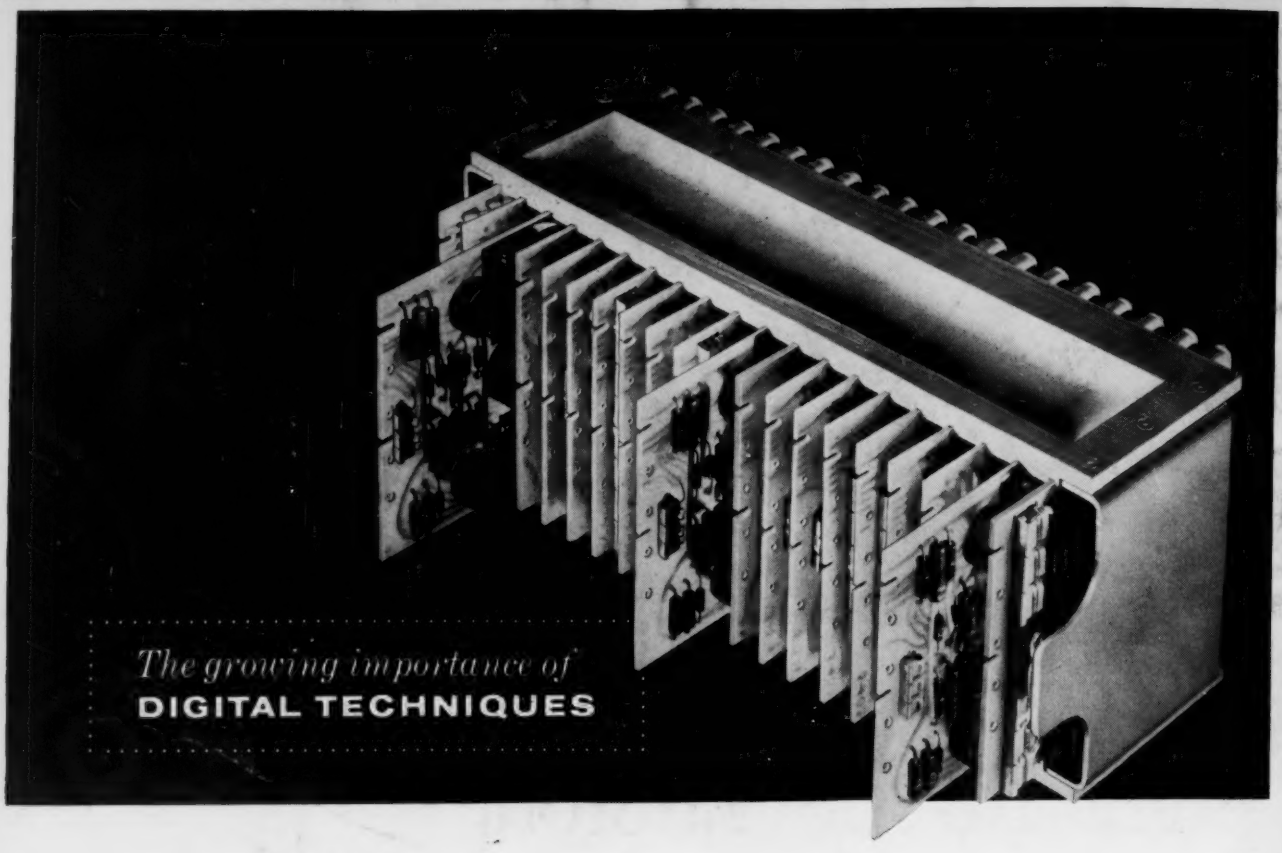

As recently as ten years ago it was just becoming evident that digital techniques in electronics were destined to create a new and rapidly growing field. Today, incorporated in electronic computers and other equipment, they constitute one of the most significant developments in scientific computation, in electronic data processing for business and industry, and in electronic control systems for the military. In the near future they are expected to become a major new factor in industrial process control systems.

The digital computer for scientific computation is becoming commonplace in research and development laboratories. Such machines range from small specialized units costing a few thousand dollars, to large general purpose computers costing over a million dollars. One of these large computers is a part of the Ramo-Wooldridge Computing Center, and a second such unit will be installed the latter part of this year. The digital computer has not only lightened the computation load for scientists and engineers, but has made possible many calculations which previously were impracticable. Such computers have played a major role in the modern systems engineering approach to complex problems.

Electronic data processing for business and industry is now well under way, based on earlier developments in electronic computers. Data processors have much in common with computers, including the utilization of digital techniques. In this field, teams of Ramo-Wooldridge specialists are providing consulting services to a variety of clients on the application of data processing equipment to their problems.

The use of digital techniques in military control systems is an accomplished fact. Modern interceptor aircraft, for example, use digital fire control systems. A number of Ramo-Wooldridge scientists and engineers have pioneered in this field, and the photograph above shows a part of an R-W-developed airborne digital computer.

These, then, are some of the aspects of the rapid growth which is taking place in the field of digital techniques. Scientists and engineers with experience in this field are invited to explore openings at The Ramo-Wooldridge Corporation in:

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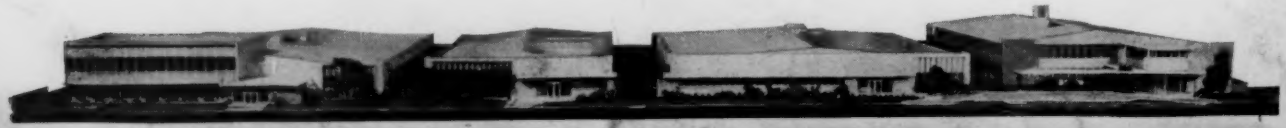
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